FEDERAL GOVERNMENT'S ROAD SAFETY INITIATIVE

YOUNG DRIVER RESEARCH PROGRAM -

A REVIEW OF INFORMATION ON YOUNG DRIVER CRASHES

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Abstract

A theoretical model of the determinants of young driver crash risk is outlined and some methodological issues concerning types of available data, measures of crash risk and measures of exposure to risk are discussed. Within this framework, published literature on young driver crashes in Australia and other countries is reviewed. The general nature and magnitude of the problem is described in terms of data on fatal and serious injury crashes derived from mass databases; information from more detailed studies of sub-sets of crashes is used to provide a more comprehensive description of the patterns of occurence and characteristics of young driver crashes. Information is discussed in relation to driver age, experience and gender, time of crash occurence, passenger characteristics, crash type, pre-crash vehicle manoeuvres, driver errors, and alcohol and seatbelt offences.

Key Words

YOUNG DRIVER, VEHICLE CRASHES, EXPERIENCE, GENDER, TIME OF DAY, DRIVER ERRORS, DRIVER BEHAVIOUR

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EXECUTIVE SUMMARY

The report outlines a theoretical model of the determinants of young driver crash risk. According to the model, driver characteristics are sub-divided into skill factors and motivation factors. Exposure to crash risk is determined by quantitative factors (distance driven), and qualitative factors (nature of the physical and social environment). Differences associated with driving at night versus driving during the day are seen to interact with many other variables within the model to affect crash risk. The literature underlying much of the theoretical model is reviewed in a separate report (Macdonald, 1994).

In the present report, published mass database information is used to document the magnitude of the young driver problem in terms of fatal and serious injury crashes. The extent of young driver involvement in less serious crashes is not discussed, since the available information is inadequate. Published information from more detailed studies of sub-sets of crashes is used to provide a more comprehensive description of the patterns of occurrence and characteristics of young driver crashes.

It is evident throughout the discussion of information about crash rates and their patterns that interpretation of crash data in terms of causal factors is difficult or impossible without more extensive and detailed information on the quantity and quality of driver exposure to crash risk than is currently available.

Results of the review are summarised below in relation to each of the following variables: driver age, driver experience, driver gender, time of crash occurrence, passenger characteristics, crash type, pre-crash vehicle manoeuvres and driver errors, alcohol and seatbelt offences.

Driver age

The relationship between driver age and crash occurrence is the central factor underlying the current research project. In general terms, young drivers are known to be over-involved in crashes. The extent and age-related pattern of young drivers' over-involvement varies somewhat in accord with the particular measure employed: crash involvement rates per head of population, per licensed driver, or per distance driven.

In terms of the first type of measure, the most common pattern is for drivers aged 18-24 to be at higher risk than older drivers, However, the pattern is by no means uniform, and it is evident that knowledge of numbers of casualties per head of population in different age groups is an unreliable index of the crash risk of young drivers actually on the road. When rates are calculated in terms of numbers of young drivers licensed, the general pattern of an increased risk for young drivers appears to be common to all jurisdictions where, as in Australia, young drivers have a significant level of exposure to crash risk.

However, calculated crash risk for young drivers relative to the numbers of young licensed drivers does not provide a satisfactory picture of relative risk between different age groups or places, because there is evidence that the quantity and quality of drivers' exposure to risk (distance driven, types of traffic environments) differs considerably between different age groups in different ways in different places. Unfortunately, there is relatively little information on young drivers' crash risk calculated to take account of the quantity and nature of their exposure to risk, relative to other age groups.

The conclusion from those studies which take account of distance driven is that crash risk is highest for young drivers, at a minimum for those in middle age, and rises again for older drivers. It remains to be seen, however, how relative risk levels of

drivers of different age groups might be changed if allowances were made for the quality of their exposure as well as its quantity.

Driver experience

In countries such as Australia, driver experience overlaps to a large extent with driver age, so the effects of these two factors are generally confounded. There is relatively little information from which the effects of experience independent of age can be determined.

It was tentatively concluded that while both age and experience may be significant determinants of crash risk, age tends to predominate among young males. For older people, and probably for females, experience has a larger effect than for young males.

Driver gender

Mass crash data are commonly reported separately for males and females, with males typically being involved in more crashes than females. Such differences are at least partially explicable in terms of differences in distance driven; that is, the quantity of exposure, and psychosocial differences between the genders, probably affect the quality of their exposure to crash risk. There is some evidence that such gender differences have decreased in Australia, North America and the U.K. over recent years.

In terms of driving behaviour, there is evidence that young male drivers are more likely than young females to be involved in crashes due to excessive speed, while young female drivers appear to be involved more often than males due to inadequate driving skills.

Time of crash occurrence

It is clear that exposure to risk is again a dominant factor determining variations in crash rates at different times of the day and the week for drivers of different ages. In studies which make no allowance for exposure, young drivers (particularly males) have very much higher crash rates at nights and weekends. However, when an attempt is made to allow for the proportion of time spent by different age groups driving at night and weekends, the pattern is much less clear cut.

Methods used to estimate exposure vary between different studies, and this may partly explain the differences in results obtained. Undifferentiated 'distance driven' data for different age groups is not sufficient; information on distance driven at different times is required, together with information on other aspects of exposure 'quality'.

Passenger characteristics

There is little which can be concluded from available evidence on the possible role of passengers as causal factors in young driver crashes. Information is needed on the numbers and characteristics of passengers normally carried by drivers of different ages at different times and places. Without such information no conclusions can be drawn concerning the possible causal role of passengers in young driver crashes.

Crash type, pre-crash vehicle manoeuvres and driver errors

The youngest and most inexperienced drivers (usually late teenagers) are involved in a greater proportion of single vehicle crashes than older drivers, particularly young male drivers at night. Such single-vehicle crashes typically involve running off the road, often due to excessive speed or 'reckless driving', and are more common in rural areas.

Other crash types in which some studies have found young drivers to be over-represented are head on, overtaking, and rear-end (young driver in rear vehicle). However, there is conflicting evidence on the latter type: some studies have specifically noted that young drivers were *not* over-represented in crashes due to 'following too closely'.

Very young drivers appear to be involved in crashes due to poor vehicle control skills more often than in the case of older drivers, and are more often responsible for causing the accident. (The oldest drivers are also 'at fault' in a high proportion of their crashes).

Inattention or failure to anticipate was identified as a problem in the older group of young drivers (aged in their early 20s), especially males; this problem appears to be associated with perceptual and cognitive errors. Drivers in this age group also tend to have a high rate of alcohol involvement.

Alcohol and seatbelt offences

The highest percentage of alcohol-related fatal crashes in Australia appear from available data to be in the 21-29 years age group; the youngest drivers (16-20 years) have a relatively low rate of alcohol involvement. This pattern is generally consistent with that in North America and the U.K.

There is very little information on the relationship between driver age and seatbelt wearing in the context of crash occurrence. There is some evidence that wearing rates are relatively low among young drivers (although not among the youngest drivers), and that non-wearing is associated with other non-driving behaviours which increase risk in some way (eg. poor vehicle condition, excessive BAC, greater number of passengers).

1.0 INTRODUCTION

1.1 Aims

The primary aims of this review are:

- to outline some of the major conceptual issues underlying the young driver crash problem, and to present a theoretical framework for the project
- to present information on the magnitude of the young driver crash problem at the international level
- to describe the nature of the problem in terms of information available from published studies of crash occurrence.

Note that more detailed substantiation of the theoretical framework is provided in a separate review of literature on young driver behaviour, performance characteristics and crash risk (Macdonald, 1993). However, the model is outlined here to provide a theoretical framework for the present review.

It is not the aim of the present report to analyse Australian mass crash database information. Such data are presented in a series of separate reports (Bowland, Yeo, Cavallo and Macdonald, 1993a, b, c, d, e; Hancock, Bowland, Yeo, Cavallo and Macdonald, 1993a, b, c, d; Macdonald, Bowland and Hancock, 1993; Yeo, Bowland, Cavallo and Macdonald, 1993). Rather, the present purpose is to summarise published information derived from crash databases of other countries and from studies which have focussed specifically on the characteristics of crashes involving young drivers.

1.2 Structure of the review

Section 2 presents a model of the determinants of young driver crash risk and discussion of the major conceptual issues underlying the problem (see Macdonald, 1993 for a more detailed discussion). In Section 3 some methodological issues related to the estimation of crash risk are discussed; in particular, types of available information, possible measures of risk and measures of exposure to risk. Section 4 presents an analysis of the magnitude and nature of the problem based on data from mass databases on road crashes and from more detailed studies of crashes. The patterns of occurrence and characteristics of young driver crashes are described in terms of data derived from crashes. Finally, Section 5 presents an overview of the theoretical framework and of major conclusions from the literature reviewed.

In a subsequent report, the nature of underlying causal processes will be examined by reviewing information on personal and behavioural characteristics of young drivers. Conclusions from the 'behavioural' literature will be related to those from the 'crash' literature reviewed in the present report.

2.0 CONCEPTUAL ISSUES IN YOUNG DRIVER SAFETY

2.1 A Model of the determinants of young driver crash risk

As shown in Figure 1, the factors which contribute to young driver crash risk may be divided into two broad categories: factors determining a driver's **exposure to crash risk** (*external* to the individual driver), and **driver characteristics** (*internal* to the individual driver). According to the model, crash risk is determined by the interacting effects of these two sets of factors.

2.1.1 Exposure to crash risk

Two important points should be noted about the factors determining exposure:

1. They are subdivided into a *quantitative* factor (distance driven) and a number of *qualitative* factors determining the *nature* of the distance driven.

   Qualitative factors include:

   - physical characteristics of the road traffic environment which affect the nature and difficulty of the driver's task, and hence crash risk

   - social characteristics of the driving such as trip purpose (travel to work, recreational, etc) and passenger factors (presence/absence, number, relationship with driver, etc).

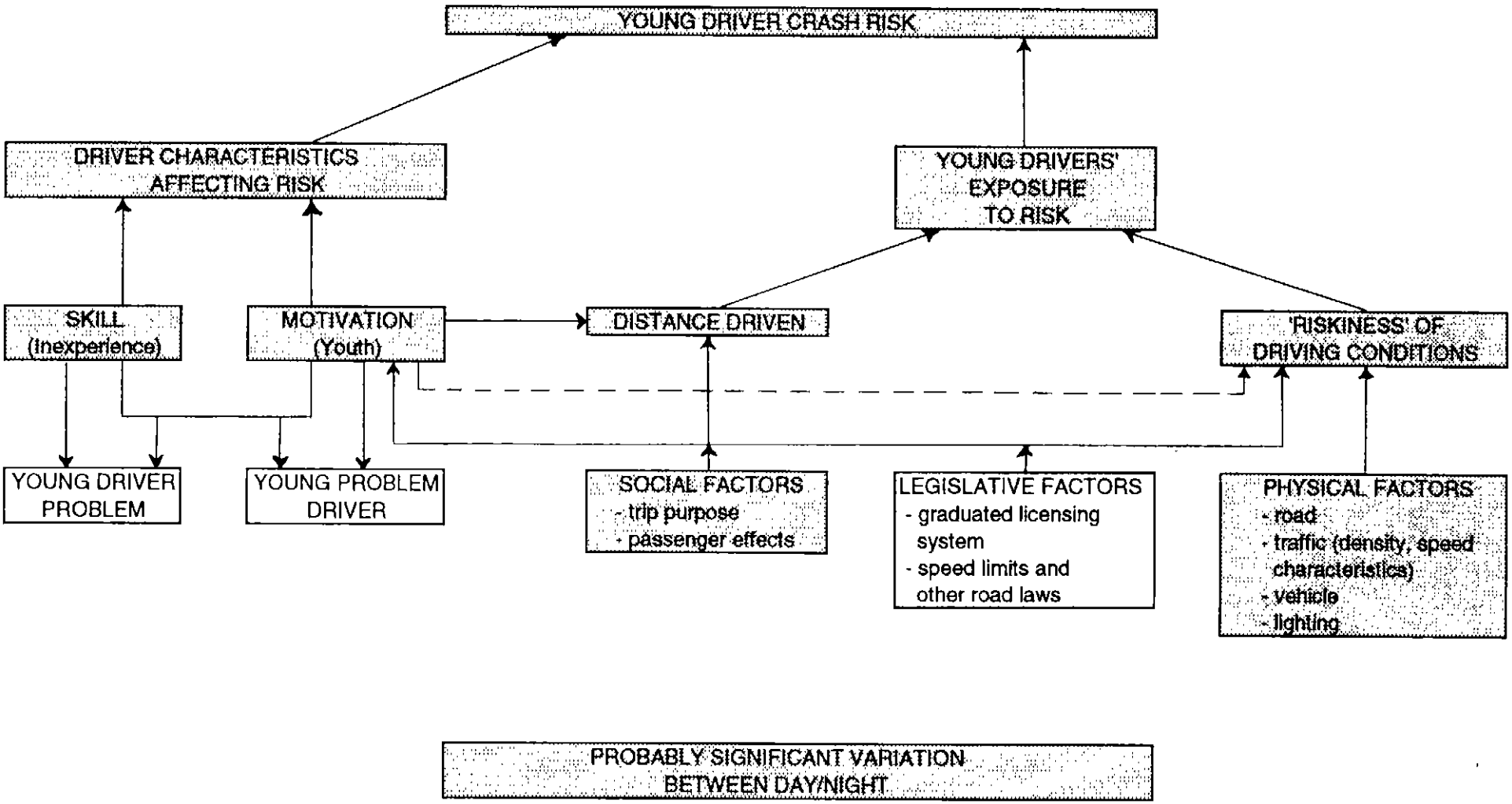
2. There are likely to be significant interactions both *within* the factors which determine overall exposure, and *between* exposure factors and driver characteristics.

2.1.2 Driver characteristics

These are subdivided into 'skill' factors and 'motivation' factors. Lack of skill is generally associated with inexperience as a driver, while 'high risk' motives tend to be associated with younger drivers. The relative importance of skill versus motivation as determinants of young drivers' crash risk is uncertain.

A closely related question is the extent to which the over-representation of young drivers in crashes is a 'Young Driver Problem' or is due to the 'Young Problem Driver'. The former explanation is based on the assumption that the elevated crash risk of young drivers is primarily due to a set of characteristics and circumstances common to *most* young drivers (that is, it is a young driver problem). In this case, lack of skill is likely to be a major factor. Motivation is also likely to be a factor, but one that would be difficult, if not impossible, to modify.

FIGURE 1: CONTRIBUTORY FACTORS TO YOUNG DRIVER CRASH RISK



The latter explanation is based on the assumption that there is a subset of young drivers (young problem drivers) who are largely responsible for the elevated crash risk. To the extent that the Young Problem Driver explanation is valid, the problem seems likely to consist primarily of motivational factors which influence both the nature of driving performance and decisions to drive under particular conditions. Inexperience and associated skill deficits are seen as less important factors from this viewpoint.

The relative influence of skill and motivational factors on young driver crash risk will be evaluated in future research, within the context of a comparative evaluation of the 'Young Problem Driver' and 'Young Driver Problem' explanations.

Interaction of the various factors depicted in Figure 1 results in a given level of crash risk. It is known that this level is significantly higher at night than during the day. In view of this day/night difference in risk, and its implications for potential crash countermeasures, the role of day/night variation in crash causation will be a focus of future research activity to explore the epidemiology and behavioural processes involved in young driver crash causation at night compared with during the day.

The major components in the model of crash risk depicted in Figure 1 are discussed further below. The possible ways in which day/night differences interact with differences in driver skill, motivation and exposure to crash risk are also considered.

2.2 Skill factors

Due to their relative lack of driving experience, young drivers tend to have lower levels of driving skill than more experienced drivers.

Low levels of driving skill may be characterised by:

- lack of skill in acquiring and integrating information
- lack of attentional capacity to process information
- lack of skill in attention-switching
- expectancies which are inaccurate and relatively undetailed
- lack of vehicle control skills.

There is an urgent need for research to elucidate the precise nature of these closely inter-related characteristics and their relative importance in the causation of young driver crashes.

2.2.1 Lack of skill in acquiring and integrating information

Empirical studies have shown that lack of driving experience is associated with less effective strategies of visual information acquisition and a lesser ability to integrate perceived information into a holistic view of the driving situation and its attendant risks.

2.2.2 Lack of attentional capacity

Lack of driving experience is associated both with a lesser amount of 'attentional capacity' with which to cope with sudden difficulties, and with a less effective strategy of allocating available attention between different aspects of the task, and between task and non-task activities.

The relatively low level of attentional capacity at the disposal of young drivers can be understood in terms of the process by which skill develops. The development of skill is accompanied by increasing 'automation' of components of the activity; with the increase in automation of a component there is a concomitant decrease in its demand for conscious attention to be paid to it during performance, which releases attentional capacity for application to other aspects of behaviour.

Thus, an inexperienced driver's patterns of attention allocation can be seen as a function of the degree of automation of different components of the overall task, and of the total amount of available attention. For example, when driving skill is in its early stages of development, drivers typically devote little attention to distant events, concentrating their limited capacity on the more immediate aspects of their task.

2.2.3 Lack of skill in attention switching

Attention allocation is also affected by skill in the process of switching attention between different components of the activity. Attention switching is itself a skill which requires practice on that specific task to develop; inexperienced drivers may simply lack skill in this process.

2.2.4 Expectancies which are inaccurate and relatively undetailed

Another important determinant of attention allocation is the perceived significance of objects and events, both current and potential. With increasing experience drivers develop more accurate and detailed 'mental models' of traffic situations, so that their expectancies of 'what might happen next' correspond better with reality. Since a driver's expectancies are an important determinant of the perceived significance of different components of the traffic situation, it would be expected that the more accurate expectancies of experienced drivers would produce a more effective pattern of attention allocation than that of inexperienced drivers.

Role of expectancies at night

It can be predicted on theoretical grounds that the poor quality of inexperienced drivers' mental models and associated expectancies would present particular dangers at night, when information from the driving environment is impoverished due to the lower light levels. In these circumstances the importance of detailed and accurate

expectancies would be maximised, since drivers must presumably use them to 'fill in the gaps' in directly observed information. That is, drivers would be expected to place greater reliance on their expectancies when visual information is degraded (as at night) than otherwise. This would place inexperienced drivers at a relative disadvantage.

Underlying this problem is a tendency to ignore or underestimate the potential significance of information when it is inconspicuous or absent compared to information which is easily visible. This general characteristic of human decision-making behaviour would mean that *all* drivers at night, or in other conditions where hazards are not immediately or easily visible, would tend to ignore invisible or inconspicuous hazards, or to underestimate their significance. However, the more detailed mental models and more accurate expectancies of experienced drivers would provide better protection against this tendency than would be the case for inexperienced drivers.

Thus, driving at night increases exposure to risk of all drivers, but more so for inexperienced drivers because of their lower levels of perceptual/cognitive driving skills. If traffic speeds were generally higher at night, the effect of degraded visual information on young drivers' crash risk would be increased, since available perception and decision time decreases as speed increases.

2.2.5 Lack of vehicle control skill

Apart from the perceptual and cognitive aspects of driving skill, it is possible that the time taken to develop skill in controlling the vehicle may take longer than has sometimes been thought. Young drivers' less developed vehicle control skill may be evident in a lower level of control performance, and/or in less attention being available for other components of the driving task. They may have a smaller repertoire of responses available to handle critical situations than would be available to more experienced drivers.

2.3 Motivation factors

Due to their youthfulness, young drivers tend to have some needs and motives different from those of older drivers, which may lead them to:

- exhibit a greater readiness to 'take risks' in the process of driving (eg speeding, following closely, reckless manoeuvres of various sorts)

- make a greater proportion of their trips under conditions which increase exposure to risk of crashing (eg at night, with passengers, 'recreational' trips).

Thus, in terms of the model, motivation may increase crash risk directly by its effect on driving performance, and/or less directly by its influence on the quantity and quality of young drivers' exposure to risk.

2.3.1 Youthful motives and risky decision making during driving

Risk taking

Driving at normal speeds under modern traffic conditions is an intrinsically risky activity; that is, errors in driving performance may have disastrous consequences. Thus, a driver's decision-making activity may be seen as a process which is influenced by motives concerning risk-taking; avoiding risk, or deliberately 'risk-taking', or maintaining risk at some individual level of acceptable risk (the emphasis varying within different theoretical frameworks).

Driving at excessively high speed is an example of 'risky' driving which young drivers are more likely than others to exhibit. This behaviour might be motivated by a variety of motives: a desire to minimise travel time; to gain pleasure from exercising driving skill, or simply from the sensation of speed itself; for the thrill of 'risk-taking' (of experiencing near-misses, perhaps); to impress others (passengers or other road users); or as an expression of generalised aggression. There is suggestive evidence that all of the above motives other than the first are more likely to occur among young than older drivers. Whether this is generally true of most young drivers, or is confined to a subset of 'young problem drivers', is uncertain. Following too close to the car ahead is another risky behaviour which is typical of young drivers, and which may be interpreted in terms of some of the above motives.

Risk taking at night

The presence and behavioural impact of such motives no doubt varies considerably between different individuals. It appears likely, although there is no direct evidence, that the role of such motives would also vary within individual drivers according to the nature of the particular trip. It might be predicted, for example, that such motives would be more likely to be significant determinants of driving behaviour during recreational driving than during a trip to work. On this basis, nights and weekends would be times of increased risk because of the different 'quality' of drivers' exposure to risk, even if quantitative exposure (in terms of distance driven) by young drivers were constant across all time periods. Again, this might be the case for most young drivers, or only for a problem subset of them.

Unintended risk taking

Behaviours such as excessive speeding and following too closely, which are objectively risky, might be interpreted as due at least in part to a failure to identify all the potential hazards and associated risks of such behaviour. From this point of view, the behaviour might be due not so much to deliberate risk taking or risk acceptance, as to lack of skill in hazard perception and cognition. More evidence is needed in order to clarify the relative importance of, on the one hand, a lack of perceptual/cognitive driving skills due to inexperience, and on the other hand a willingness or desire, associated with youthful motives, to accept higher risk levels.

Related to the above is the driver's perception of his or her own capacity to cope with the expected nature of the driving task and its associated hazards. Drivers who perceive themselves to be particularly good drivers might be expected to be more likely to exhibit 'risky' behaviours, since they might perceive the expected hazards and associated driving task demands as not particularly risky for highly skilled drivers such as themselves. There is evidence that males are more likely than females to over-rate their own level of driving skill. This phenomenon can be categorised more as a lack of perceptual skill (in this case inaccurate perception of self - a lack of insight) than as a motivational factor.

2.3.2 Youthful motives and attention allocation

Attention allocation is affected by motivation as well as by lack of skill due to inexperience. For example, youthful drivers more often than older drivers may be motivated to avoid giving passengers the impression that they are unable to carry on a conversation while driving or that they are excessively cautious. This may lead young drivers to allocate more attention to interactions with passengers and less to their driving task, particularly in situations where the hazards are potential rather than clearly apparent.

Thus, some typically youthful motives and values may affect driving performance at a very basic level by altering the ways in which young drivers allocate attention while driving. Such motives interact closely with 'skill'-based factors in determining the content of information on which drivers base their decisions; they may be generally characteristic of young drivers, or only of a subset of young 'problem' drivers.

2.3.3 Youthful motives and exposure to risk

Quite apart from the risks associated with a driver's decisions during the driving process, there are risks associated with a decision to drive under a given set of conditions: that is, decisions made prior to driving which may determine the level of exposure to crash risk. It can be argued, for instance, that young people (either in general, or a particular subset) are more likely to want to drive at night, with passengers, and in unfamiliar areas, all of which may increase their risk of crashing independent of any tendency on their part to 'take risks' while driving. (See 'Role of expectancies at night' on page 9 and Section 2.3.2 above).

2.4 'Young problem drivers'

An important question concerning the influence of young drivers' motives on their driving behaviour is whether or not *most* young drivers are characterised by 'risky' motives such as those discussed above, or whether the problem is largely confined to a relatively small subset of young drivers: so-called 'young problem drivers'. There is currently insufficient evidence to reach a conclusion on this matter.

It is evident that nearly all young drivers lack driving experience and thus have sub-optimal driving skills which to some extent increases their risk of crashing. It is not known whether the effects of 'youthful' motives on driving performance and crash risk are similarly widespread, or whether they are largely confined to a subset of young drivers. It is also possible that some novice drivers may have specific skill deficits of a type that makes them young problem drivers.

2.5 The nature of young drivers' exposure

There is now a huge statistical database on young driver crashes, and it is clear that young, inexperienced drivers are over-represented in crashes relative to older drivers. In seeking to understand reasons for this over-representation, more detailed analyses of patterns of crash causation are needed. However the results of such analyses must be interpreted in terms of the varying exposure to risk of different categories of drivers.

Most obviously, we need to know that young drivers are over-represented in crash statistics not simply because they drive greater distances than other drivers; at least for some data sets this has already been established. However, a set distance driven on a freeway is intrinsically less risky than the same distance driven on a suburban arterial road. The risk of freeway driving can be defined as lower both by reference to crash data and in more theoretical terms by an analysis of the relative driving task demands in terms of the amount and rate of information processing required. On such a basis it might, for example, be argued that the increased involvement in crashes of young drivers was due to their spending a disproportionately small amount of their time on freeways, relative to other drivers, if this were found to be the case.

As depicted in Figure 1, 'exposure' is a multi-dimensional concept in which 'distance driven' is the major quantitative component. However, the 'qualitative' aspects of the distance driven also affect exposure. Thus, road, traffic and vehicle factors, and the presence and behaviour of passengers, together influence the nature and level of driving task demands which may change the risk of a crash. This is recognised by graduated licensing programs which are an effective crash countermeasure to the extent that they modify the quantity and/or the quality of young drivers' exposure to risk.

2.5.1 Exposure, driving task demand and day/night differences

It seems likely that the interacting effects of factors such as the above may produce a very significant difference in driving task demands between, for example, daytime driving and night-time driving at weekends.

The evidence from crash statistics is clearly supportive of such a proposition. To address this issue more directly, a a range of viable hypotheses need to be developed within the context of an appropriate theoretical framework. The degraded quality of stimulus information has been proposed as a possible significant factor in the present

example. To evaluate this further, choice of a theoretical model needs to consider which of those available will best support the quantification of the difficulty of such a task. Night driving is not associated with an excessive information load in terms of the number and complexity of information sources. However, night driving does increase the demands of visual sampling and information seeking; in addition, it may increase the unpredictability of information, perhaps related to ambiguities in visual cues from the roadway, or an increase in speed variance among other road users. An increase in unexpected manoeuvres on the part of other drivers may also play a role in increasing the demands of night driving. Such phenomena would increase the information processing load on drivers, hence increasing task difficulty.

If such is the case, then to the extent that young drivers spend relatively more of their total driving time at night than other groups of drivers, they are exposed to higher levels of risk which will to some extent explain their over-involvement in crashes.

Such arguments could be extended to include seatbelt wearing rates, which there is some evidence to suggest may be lower at night. Seatbelt wearing can be seen both as a determinant of exposure to risk and as an aspect of driver behaviour. Clearly, the definition of 'exposure' is somewhat arbitrary, and in a sense unimportant: what is clear is that seatbelt wearing is associated with both risk and with driver behaviour.

2.5.2 Driver motivation and day/night differences

Interacting with the hypothesised day/night difference in task demand and hence crash risk may be a day/night difference in driver factors. It may be that the sub-population of young drivers on the road at night, particularly at weekends, includes a higher proportion with attitudes and motives which produce higher levels of risk-taking - that is, a higher proportion of 'young problem drivers'.

3.0 SOME METHODOLOGICAL ISSUES

3.1 Types of information

The magnitude of the young driver crash problem can be described most directly using databases on crash occurrence which cover all drivers in the population. These 'mass' databases are derived from police crash reports and maintained by the state; information from these sources is probably the most commonly reported in the 'young driver' literature.

However, information from mass databases is available on only a limited range of factors. Data concerning the personal characteristics of drivers involved in crashes ('Driver Factors' in terms of Figure 1) is typically confined to their gender and age. There is usually information (although less reliable) on the number of passengers, and possibly information on their seating position within the vehicle, on whether driver and passengers were wearing seatbelts, and on the driver's blood alcohol level. However, these latter categories of information concerning specific characteristics of crash-involved people, or sub-groups of such people, are less widely reported than the overall numbers of people killed and injured.

Information on time since first licensing is not included in mass databases on crashes, so driving experience cannot be estimated without cross-reference to driver licence databases, where possible. The opinion of the attending police officer on responsibility for the crash may be recorded, but information on individual driver skills and motives is unavailable from such data.

Information is available on some of the physical characteristics related to exposure to crash risk (see Figure 1). Time of day, date and vehicle type are recorded, together with some information about the crash location and pre-crash vehicle manoeuvres. However, the crash location is not described in terms which make it generally feasible to categorise by road type or prevailing traffic conditions.

Mass data on crashes in which there are only minor injuries or which result only in property damage are notoriously incomplete and unreliable, which means that the rates at which different groups of drivers are involved in minor crashes of various sorts is poorly documented. The best available data on such crashes is probably that in insurance company files; however, it is generally not accessible to researchers.

In-depth studies of crashes in which mass database information is supplemented by additional material, including questionnaire data, are very useful in providing a more detailed descriptive account of patterns of occurrence of young driver crashes. Possible causal factors underlying the crashes can more easily be inferred from this more detailed information. In such studies drivers may report their own histories of crash involvement and some of the circumstances of their crashes. However, these data are subject to under-reporting and self-reported data on crashes are likely to be biased towards less serious crashes relative to mass databases.

In view of the above, the present report uses information from mass databases to document the magnitude of the young driver problem in terms of fatal and serious injury crashes. The extent of young driver involvement in less serious crashes is not discussed, since the available information is inadequate. Data from more detailed studies of sub-sets of crashes are used to provide a more comprehensive description of the patterns of occurrence and characteristics of young driver crashes.

3.2 Measures of crash risk

Calculations of crash risk are most reliably based on mass databases. However, information from these sources is reported in many different forms, and it is necessary to take account of the exact nature of the measure used before comparing values with those from other studies.

The most common forms of measure are absolute numbers: of fatalities, of fatalities plus serious injuries, or of crashes involving fatalities and serious injuries. These are reported for drivers separately, for other sub-groups separately, or for everyone combined. In some cases these numbers are expressed as rates: per head of population, or per licence holder. Any of these measures may be an appropriate means of describing the young driver crash problem from a public health perspective: that is, when the aim is to minimise absolute numbers of deaths and injuries.

However, if the application of the information is not simply to minimise numbers of injuries and fatalities, then a purely public health perspective may not be justified. For example, if some value is placed on maximising mobility, or personal convenience and satisfaction, as well as on minimising injuries, it becomes important to quantify risk of injury in terms of an index which takes account of the level of mobility, or whatever, achieved. Typically this would suggest an index of risk which takes account of distance driven by the sub-population of drivers of interest. Numbers of fatalities and injuries are then able to be expressed as a rate per standard distance rather than per licence holder.

Unfortunately, there are relatively few studies which report crash data in this way, although the importance of doing so is recently receiving much wider recognition. A 1991 report from the UK Transport and Road Research Laboratory by Maycock, Lockwood and Lester on "The Accident Liability of Car Drivers" stated in the introductory review of literature that "*In order to be wholly satisfactory, it was considered that studies ... should include or control for exposure (miles travelled) ...*" (pp 1-2). Maycock et al placed such importance on exposure information that they reviewed only those studies containing it.

Data expressed as absolute numbers, or as rates per head of the young population, or per young licensed driver, theoretically may reflect nothing more than the numbers of young drivers present on the road during the period in question. That is, a large number of young driver fatalities per licensed young driver might in itself mean no more than that there was a larger proportion of young licensed drivers actually 'on the road' than there were of licence holders in other age groups.

If this were the case, there would be little justification for trying to find ways to improve young drivers' skills, attitudes, or other such characteristics which might be thought to be potential means of lowering their crash risk. Such countermeasures might be warranted only if it is known that, *when on the road*, the driving behaviour of young drivers is 'riskier' than that of other age groups. To establish this, data on exposure to risk is essential. Information on 'exposure' should cover more than simply distance driven, because driving in some places (eg freeways), and at some times (eg day rather than night), is intrinsically less risky than at other times or places.

In the present report, priority is given to discussing information from studies which took account of exposure; however information from other studies is also considered. Analyses of crash databases conducted concurrently with this literature review, as part of the current study, have been unable to take account of exposure to risk because of inadequate available information. Overall, the situation described by Knapper (cited by Mayhew et al, 1985, p 25) is still largely true:

> "Knowledge of young people's exposure in different types of traffic environment is fairly crude, and limited to the generalisation that they drive more at night and at weekends. There is hardly any information about why they are driving (although common sense would suggest the purpose is primarily recreational), where they are driving to, what type of roads they are using, and so on. It seems likely that researchers will have to probe more deeply into the concept of 'exposure' - and beyond it to examine underlying social and psychological factors - if we are to gain insights that will enable us to explain fully the roots of the behaviour leading to fatal accidents."

This issue of exposure will be addressed in years 2 and 3 of the project.

3.3 Measures of exposure to risk

Calculation of crash rate per distance driven is the most common way of making allowance for exposure to risk. This is most commonly obtained by surveying representative samples of drivers, based on driver licence records. Drivers in such surveys may be asked to report on their travel for the previous day, or to maintain a travel diary for a period of several days. Such surveys have also been used to obtain information on travel time, and on number of trips.

Another means of estimating distance driven is to survey a sample of drivers at a representative sample of locations and times, obtaining information on their current trip.

Alternatively, the exposure to risk of a particular population of drivers may be estimated by calculating their 'induced exposure index'. Such an index is based on the assumption that the population of 'innocent' but crash-involved drivers are a representative sample of the general population of drivers at that time and place.

The validity of this assumption is somewhat questionable, particularly if designation of responsibility is based purely on the interpretation of events by police attending the crash. However, McKelvey et al (1987, cited by TRB, 1988) concluded from an investigation of the possible bias of investigating officers that such bias, if it existed, was not a major influence.

Matthews and Jones (undated) have argued that measures of 'induced exposure' are potentially more valid than those based on distance travelled, because they employ information about a sample of drivers who were present at precisely the same times and locations as the crash-involved drivers. It can be argued that distance driven is an inadequate index of risk exposure because it is known that driving at night, for example, is riskier than driving during the day, and driving on freeways is less risky than driving on other roads. That is, the same 'quantity' of exposure in terms of distance (or time) may vary considerably in 'quality', and hence in total amount of risk. This point of view is implicit in the statement from Knapper (1985) quoted in 3.2 above. Matthews and Jones argued that the use of an induced exposure measure ensures that variation in the quality as well as the quantity of exposure is controlled. This technique is, however, very rarely used.

Depending on the sampling procedures used (both their design and the extent of their sampling error) it seems probable that the data resulting from different types of exposure study may give significantly different estimates of actual population exposure. Data supporting such a contention was presented by Maki (1988): exposure estimates produced by a roadside survey were significantly different from induced exposure estimates, and the difference was not constant over different driver age groups, being largest for the younger age groups. In view of the importance of determining not only the quantity but the quality of driver exposure, the methodological issues associated with estimating exposure demand increased attention from researchers.

4.0 CHARACTERISTICS OF YOUNG DRIVER CRASHES

Information from mass databases and from special studies of crashes is reviewed, and the role in crashes of the following factors is discussed:

- driver age
- driver experience
- driver gender
- time of crash occurrence
- passenger characteristics
- crash type, pre-crash vehicle manoeuvres and driver errors
- alcohol and seatbelt offences.

All of these factors are documented to some extent in mass databases, and more detailed supplementary information is available from many special studies of crash occurrence. They are important in terms of the theoretical framework presented in Section 2 above, and their significance within this framework is outlined below.

Driver age is the most basic driver factor, in that it defines the target group for the present project. Age is associated with motivational and social factors which affect both driver performance characteristics and driver exposure to risk.

In societies such as Australia, *driver experience* is closely correlated with age . It is the driver factor which most directly affects driving skill.

Driver gender is a third driver factor which, in combination with driver age, is known to be related to differences in motivation, skill and social factors. It thus affects both driver characteristics determining crash risk (skill and motivation) and exposure to risk (social factors).

Time of crash occurrence defines both day/night and weekday/weekend. Important variables affected by these divisions are motivational and social factors related to trip purpose and passenger effects, and physical environment factors, particularly lighting (day/night) and traffic conditions. These physical factors affect task difficulty, varying the demands made by the environment on young drivers' limited skills.

Passenger characteristics - their number, age and sex in relation to that of the driver - affect the environment in which the driver operates and hence interact with the driver's skill and motivational characteristics. They also affect the magnitude of risk for any one driver from a public health perspective, affecting the potential consequences of a crash in terms of numbers of people killed or injured. The latter aspect is not a focus of interest in the present report, but is addressed in other components of the project.

Crash type and *pre-crash vehicle manoeuvres* reflect aspects of both exposure to risk and driving performance. *Driver errors*, responsibility for the crash and related offences are primarily seen as evidence of level of driving performance. Some driver

errors and offences may be interpreted as indicating specific driver deficits in either skill or motivational characteristics.

Alcohol and seatbelt offences may be seen both as aspects of driver behaviour which reflect more general attitudes (associated with but not part of driving itself), and as important determinants of exposure to crash risk.

4.1 Driver age

The relationship between driver age and crash occurrence is the central factor underlying the current research project. In general terms the nature of the relationship has been very well researched and is well known. To quote from a recent Canadian report: "The conclusions of major reports on this subject are remarkably consistent - young drivers are over-represented in road crashes." (IBC, 1991, p 1).

The extent and age-related pattern of this over-involvement varies somewhat in accord with the particular measure employed. Following is a representative sample of findings, divided into sections according to whether the measure of young driver crash involvement or 'risk' is based on crash involvement rates per head of population, per licensed driver, or per distance driven.

4.1.1 Rates per head of population

British crash rates (Department of Transport, 1989) per 100,000 population for numbers of 1988 car drivers in different age groups killed, killed plus seriously injured (KSI), and all severity levels are shown in Table 1 below.

Table 1: United Kingdom driver casualty rates for different age groups in 1989, per 100,000 population; figures are shown separately for drivers killed, killed and seriously injured, and all levels of severity.

	Driver age group						
Drivers:	**17-19**	**20-29**	**30-39**	**40-49**	**50-59**	**60-69**	**70+**
Killed	5.0	4.5	2.7	2.5	2.0	1.9	2.3
KSI	87	68	43	33	26	19	16
All severities	483	394	259	196	147	93	64

Presented in Table 2 are USA and European data on the risk per head of population in different age groups for driver fatalities in 1987, derived from information in "Statistics of Road Traffic Accidents in Europe" (UN, 1989). The figures presented were obtained by dividing the percentage of driver fatalities in each age group by the percentage of the driver-age population in that age group. The result is a 'risk ratio' where values greater than 1 represent a higher risk than would be expected purely on the basis of the number of people in the population within that age group.

Table 2: Risk ratios (percentage killed divided by corresponding population percentage) for driver fatalities in the USA and some European countries (derived from a report by the UN, 1989). Number of motor vehicles per 1,000 population (Mt*) is shown in the last column.

	Driver age group					
	15-17	**18-20**	**21-24**	**25-64**	**65+**	**Mt***
Austria	0.0	**2.7**	**2.4**	0.9	0.4	522
Czechoslovakia	0.0	1.0	**1.3**	**1.2**	0.4	219
Denmark	0.2	**2.1**	1.7	0.9	1.0	400
Finland	0.3	**3.3**	**2.0**	0.8	0.8	427
France	0.0	**1.3**	**2.1**	1.0	0.7	542
Germany	0.1	**3.1**	**2.4**	0.8	0.5	531
Greece	0.2	0.8	**1.4**	**1.2**	0.3	230
Hungary	0.2	**1.5**	**1.9**	**1.1**	0.3	214
Netherlands	0.1	**1.6**	**2.0**	0.9	**1.1**	429
Norway	0.2	**4.1**	**1.8**	0.7	0.7	499
Sweden	0.4	**2.3**	**1.6**	0.9	0.9	461
Switzerland	0.1	**2.5**	**2.5**	0.8	0.6	581
UK	0.4	**2.3**	**1.8**	0.9	0.8	398
USA	**1.1**	**2.1**	1.7	0.8	0.9	784
Yugoslavia	0.0	0.6	**1.6**	**1.2**	0.2	169

It can be seen that the most common pattern among the countries presented in Table 2 is for drivers aged 18-24 to be at higher risk and drivers aged 25 and over to be at a lower risk. However, the pattern is by no means uniform. For example, Greek and Yugoslavian drivers aged 18-20 are under-represented in fatal crashes, and Czechoslovakian, Greek, Hungarian and Yugoslavian drivers aged 25-64 years are over-represented. Drivers aged 15-17 are under-represented in all countries except the USA.

It appears most unlikely that the major factor underlying the above differences between countries in crash risk within age groups is a difference in driver behaviour. That is, it is unlikely that the youngest drivers in the USA drive in a riskier fashion than those of the same age in other countries, or that Czechoslovakian, Greek, Hungarian and Yugoslavian drivers aged 25-64 are much riskier drivers than those in other countries. The different patterns of risk are more probably due to differences between these countries in the proportions of the population who are drivers, both overall and for particular age groups. It is no doubt significant in this context that Czechoslovakia, Greece, Hungary and Yugoslavia have the four lowest numbers of vehicles per head of population shown in Table 2, while the USA has the highest number.

It appears, then, that knowledge of numbers of casualties per head of population in different age groups is an unreliable index of the crash risk of young drivers actually on the road.

4.1.2 Rates per licensed driver

A different pattern might be presented if the risk ratios were calculated on the basis of numbers of licensed drivers in each age group, rather than numbers of people in the population for each age group. Unfortunately, this information was not available for most of the countries appearing in Table 2. A typical pattern based on such information is shown in Figure 2.

There are many other studies in which crash risk per licensed driver is presented. For example, Hofner (1989) reported that Austrian drivers below 25 were only 20% of the driving population but were involved in more than 50% of all injury crashes. Similarly, a report on Belgian road crash data and young drivers (van den Meersschaut, 1989) pointed out that 18-24 year olds were only 11% of the population but were involved in a much larger proportion of road crashes.

Information for the UK was presented in graphical form by Broughton (1988). It is shown here in Figure 3.

Figure 2. USA rates by age and sex per driver and per population for fatal crashes in the USA, 1990 (US Department of Transportation, 1991, p 151).

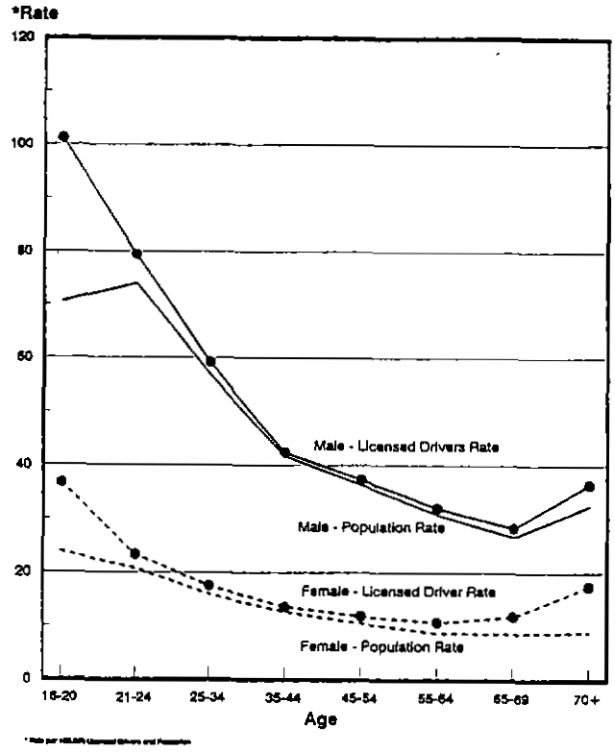
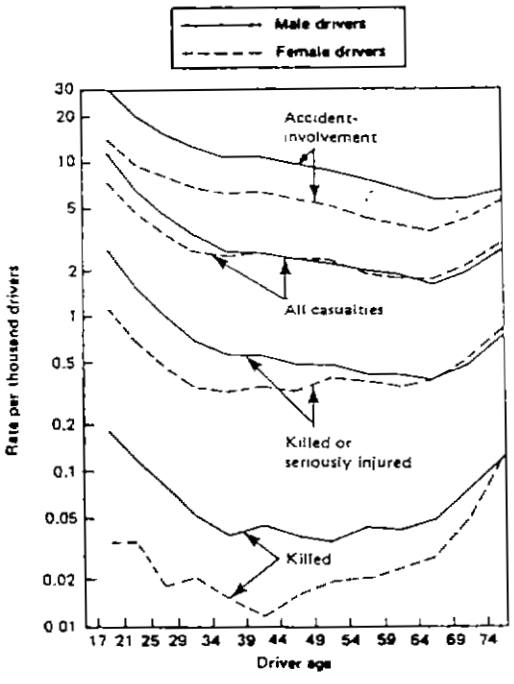


Figure 3. Crash involvement and casualty rates per thousand car drivers for the UK, 1985 (from Broughton, 1988, p 4).



Western Australian data for 1989 on the relationship between driver age and casualty crash rate per licence holder of that age (Baxter, van Brakel and Maisey, 1990, p 28) were used to derive relative risk ratios for each age group; these are shown in Table 3. Each figure in the table is the percentage of casualty crashes in which drivers of a given age group were involved, divided by the percentage of licence holders in that age group. (It was assumed that the 14% of drivers of unknown age were distributed evenly across age groups).

Table 3: Relative risk of casualty crash involvement of Western Australian drivers of different age groups, per licence holder (derived from Baxter et al, 1990).

Driver age group							
<21	**21-24**	**25-29**	**30-39**	**40-49**	**50-59**	**60-75**	**75+**
2.6	**1.6**	**1.2**	0.8	0.7	0.7	0.5	0.5

South Australian data for the period 1981-1988 (ORS, 1990) were used to derive relative risk ratios for driver casualties per licence holders within each of three age groups, shown in Table 4. Each figure is the percentage of driver casualties for that age group divided by the percentage of licence holders in the age group.

Table 4: Relative risk of casualty crash for South Australian drivers of different age groups, per licence holder (derived from ORS, 1990).

Driver age group		
16-24	**26-59**	**60+**
1.9	0.8	0.6

Similar data on relative risk levels for different age groups for New South Wales in 1990 are shown in Table 5.

Table 5: Relative crash risk per licence holder for New South Wales drivers of different age groups (derived from NSW R&TA, 1991).

	Driver age group							
	17-20	**21-25**	**26-29**	**30-39**	**40-49**	**50-59**	**60-69**	**70+**
Fatals	**2.7**	**1.3**	0.9	0.7	0.7	0.7	0.9	0.5
All casualties	**2.9**	**1.6**	**1.1**	0.8	0.7	0.6	0.6	1.0

Canadian experience (Mayhew and Simpson, 1990) is represented in Figures 4 and 5, showing Ontario data for different age groups over the years 1979-1987; Figure 4 shows crash rates per 10,000 licensed drivers and Figure 5 shows drivers killed per 10,000 licensed drivers. It can be seen that the younger drivers had rates consistently two to three times higher than those of older drivers.

Figure 4: Crash rates (per 10,000 licensed drivers) for drivers of different age groups in Ontario from 1979-1987 (from Mayhew and Simpson, 1990, p 38).

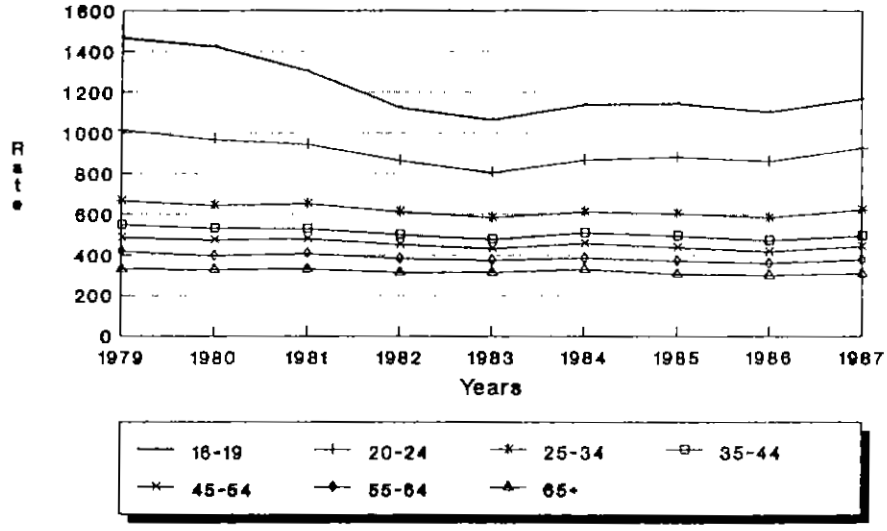
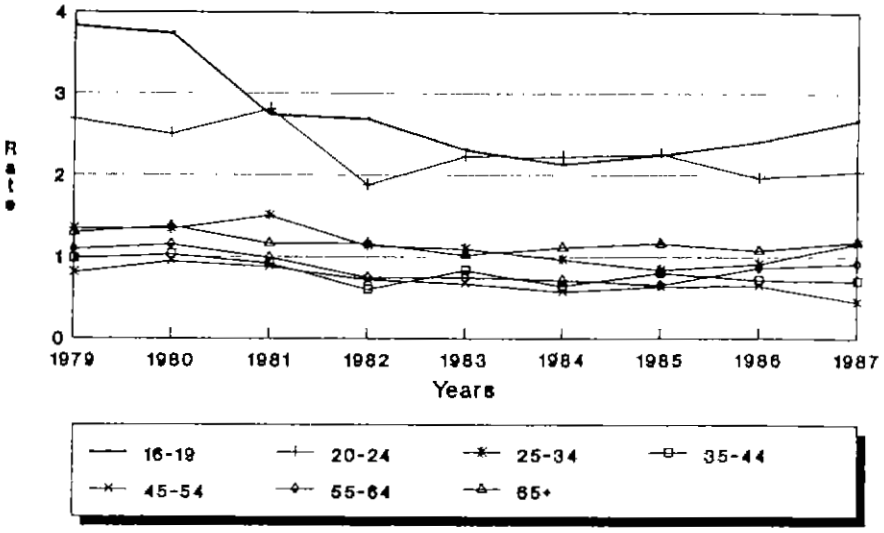


Figure 5: Drivers killed (per 10,000 licensed drivers) in different age groups in Ontario from 1979-1987 (from Mayhew and Simpson, 1990, p 43).



Overall, the general pattern of an increased risk for young drivers, relative to the number of young drivers licensed, appears to be common to all jurisdictions where, as in Australia, young drivers have a significant level of exposure.

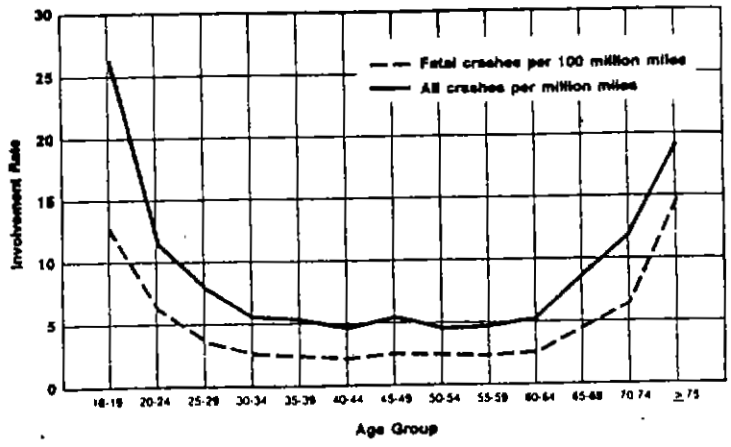
4.1.3 Rates per distance driven

Calculation of crash risk for young drivers relative to the numbers of young licensed drivers is not a very satisfactory method of determining risk levels for young drivers actually on the road at any given time or place. That is, such data do not provide a comprehensive picture of relative risk between different age groups or places, because the quantity and quality of drivers' exposure to risk (distance driven, types of traffic environments) probably differs considerably between different age groups in different ways in different places. Again, the importance of information on the exposure to risk of the particular groups of drivers in question is seen to be critical.

Unfortunately, there is relatively little information on young drivers' crash risk calculated to take account of their relative exposure to risk. It is not easily available from mass databases.

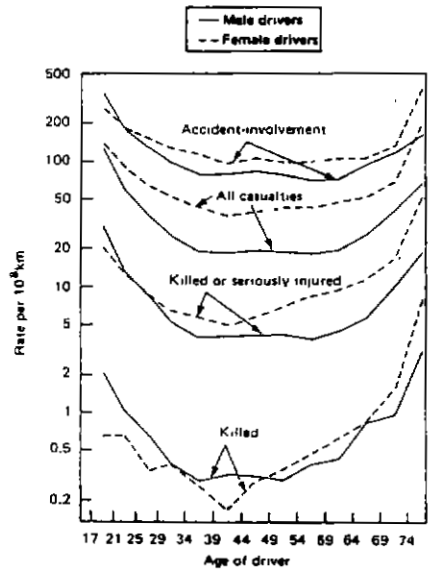
Williams and Carsten (1989) summarised data on the relationship between driver age and crash involvement in the USA, drawing on 1983 data from the Fatal Accident Reporting System (FARS), 1982-84 data from the National Accident Sampling System (NASS: a representative sample of all police-reported crashes) and the 1983 National Personal Transportation Study. As shown in Figure 6 below, crash rates per distance travelled for both fatal crashes (FARS) and all crashes (NASS) were highest for the youngest age groups. For the youngest age group (16-19 years) fatal crash rate relative to overall crash rate was particularly high.

Figure 6: Distance-based crash rates by driver age, USA, 1983 (from Williams and Carsten, 1989, p 326).



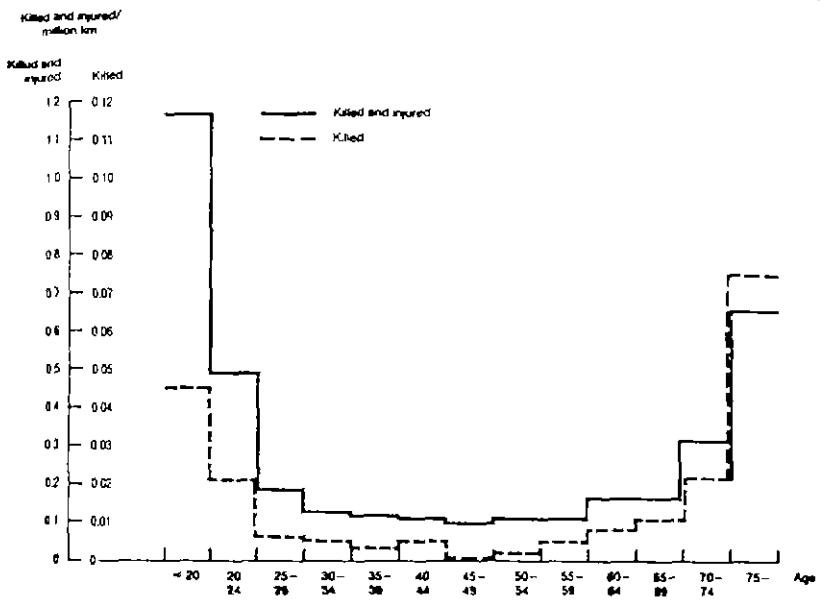
Broughton (1988) reported a similar pattern for 1985 British data. Figure 7 shows these data; male and female rates are shown separately. Broughton noted that the 1978/9 National Travel Survey data used in calculating these rates were known to have underestimated total mileage, possibly more so for certain age groups.

Figure 7: Crash involvement and casualty rates per 10^8 km travelled, UK, 1985 (from Broughton, 1988, p 5).



Numbers of drivers killed and injured in Denmark per distance driven is shown in Figure 8 for various age groups (ECME, 1989).

Figure 8: Drivers per million km killed and injured for different age groups in Denmark (from ECME, 1989).



Californian data on crashes per 100,000 miles driven for drivers of different ages were described by Peck (1985), and are shown in Figure 9. Stewart and Sanderson (1985; cited by Mayhew and Simpson, 1990) presented similar results from an analysis of driver fatalities and injuries per distance driven for Canadian drivers of different ages. These results are shown in Figure 10. In both cases the over-representation of very young drivers is evident.

Figure 9: Crashes per 100.000 miles, by age and sex, California, 1980-82 (from Peck, 1985, p 53).

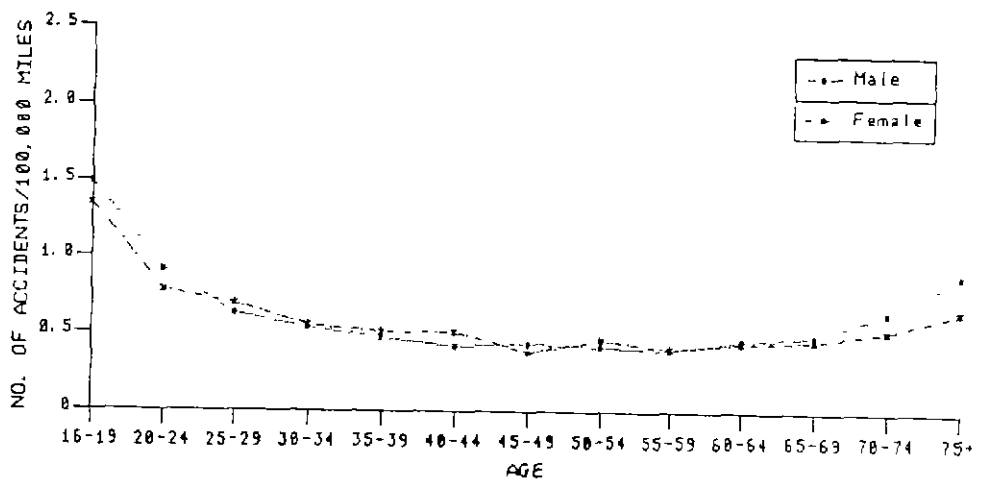
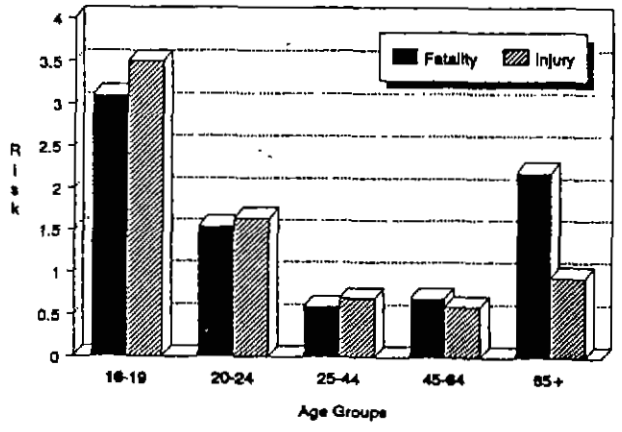


Figure 10: Relative risk of fatality and injury by driver age, Canada. (from Stewart and Sanderson, 1985, cited by Mayhew and Simpson, 1990, p 60).



Drummond (1988) presented data from Victoria in terms of the relative risk of crash involvement per 10^6 kilometres driven for drivers of different durations of driving experience (time since licensing) - a variable with a high degree of overlap with age. He reported that drivers with up to one year of experience (most of whom would be aged 18-20), had a risk of casualty crash involvement 2.7 times higher than that of drivers with three or more years experience (all of whom would be at least 21 years of age, with an average considerably higher).

Anderson, Montesin and Adena (1989) presented data on Australian road crash fatality rates, calculating rates in terms of distance travelled, time spent driving, and number of trips taken. These various forms of exposure data were derived from the Survey of Day-to-Day Travel in Australia 1985-86. They found that "... the fatality rate for car drivers was markedly different for various age groups, being highest for young drivers, at a minimum for those in middle age but rising again for drivers over 60" (p 3).

It is concluded from the above studies that young drivers can be expected to have a relatively high crash risk, both per licensed driver and per distance driven. It remains to be seen, however, how relative risk levels of drivers of different age groups might be changed if allowances were made for the quality of their exposure as well as its quantity.

4.2 Driver experience

As noted earlier, in highly motorised countries such as Australia, driver experience overlaps to a large extent with driver age, so the effects of these two factors are generally confounded. Since age is more commonly reported, and information on age

is generally more reliable than that on experience, there is relatively little information from which the effects of experience independent of age can be determined.

O'Connor (1986) concluded from an analysis of 1986 South Australian crash data together with a literature review, that age is a stronger predictor of crashes than driving experience.

Lewis (1985) referred to McDonald (1976) who found that driving experience was one of the factors discriminating drivers whose crash-related behaviour had been culpable from drivers whose behaviour had been non-culpable. Inexperienced female drivers were significantly more likely than experienced female drivers to have exhibited culpable driving, causing the crash, even after controlling for the effects of age. Controlling for age, experience was not similarly related to culpability for males. (However, there was probably a higher correlation between age and experience for males, which may have masked the effects of experience.)

Brown, Groeger and Biehl (1987) quoted the classic study of Pelz and Schuman (1971) which showed that crash involvement reaches a peak some two or three years after people learn to drive and then gradually tails off. At this peak, male drivers were involved in over four times, and female drivers over twice, the number of crashes commonly experienced by drivers 35-45 years old.

Knapper (1985) cited findings of Mayhew, Warren, Simpson and Haas (1981) that whereas the fatality rate of young female drivers was highest at age 16, when their driving inexperience was greatest, for males there was no difference in fatality rate for drivers between ages 16 to 19 years. Pelz and Schuman (1971) similarly found that for teenage males, crash risk did not necessarily decrease with increasing experience.

Thus, there is some suggestive but far from conclusive evidence that age has a more dominant effect on crash risk for males than for females. However, Knapper (1985) noted that driving experience is not a unidimensional quantity: the same amount of experience in terms of distance driven may vary in quality (or 'value' as a means of reducing crash risk) depending on such factors as the different times of day, types of road, urban versus rural environments, different speeds, weather conditions, etc experienced during that time. It was suggested that the quality of male and female experience tends to differ in such ways.

Canadian researchers have recently been responsible for the most comprehensive evaluation of the relative effects of age versus experience on crash risk (IBC, 1991). Based on comprehensive analyses of Canadian crash studies and the research literature (Mayhew, Simpson and Donelson, 1985; Mayhew and Simpson, 1990) it was tentatively concluded "that age-related factors are more strongly associated with collision risk than are those that are experientially related" (Mayhew and Simpson, 1990, p xii).

This conclusion was clarified a little in the most recent report from Canadian researchers, presenting key findings from an international symposium on this topic (IBC, 1991). It was explained that the relative impact of age and experience is

dependent on their manner of interaction. Specifically, the effect of three years driving experience in reducing the crash risk of novice drivers is evidently greater for older novices than for young ones: the difference in crash risk between an inexperienced and an experienced 30-year-old is about 38%, whereas there is only about an 8% difference between the crash risk of two 20-year-olds differing in experience to the same extent.

It is tentatively concluded, then, that both age and experience may be significant determinants of crash risk. For young males, age tends to predominate. For older people, and probably for females, experience has a larger effect than in the case of young males.

4.3 Driver gender

Mass crash data are commonly reported separately for males and females, with males typically being involved in more crashes than females. Such differences are at least partially explicable in terms of differences in distance driven, that is, the quantity of exposure. Psychosocial differences between the genders probably also affect the quality of their exposure to crash risk. Differences between males and females in exposure are discussed in Section 4.3.3 below.

Also, there is some evidence that gender-related differences in driving behaviour or style may be an additional cause of gender-related differences in crash involvement. This is discussed in Section 4.3.5.

4.3.1 Gender differences in risk with no allowance for exposure

New York data for 1987 (New York State Department of Motor Vehicles, 1990, p 51) are shown in Table 6 below.

Table 6: Relative male:female driver risk for fatal, injury and all crashes, by age groups, New York, 1987 (NY DMV, 1990).

	Drivers: Male to female ratios		
Age group	**Deaths**	**Injury**	**Total crashes**
18-20	4.2	2.0	2.1
21-24	4.6	2.2	2.1
25-29	4.8	2.3	2.3
30-39	3.6	2.1	2.1
40-49	4.2	1.9	1.9
50-59	3.8	2.7	2.1
60-64	4.0	2.3	2.3
65+	2.3	2.2	2.2

It appears from Table 6 that risk of crash involvement and of injury is reasonably constant across age groups, with males having a little more than twice the risk of females. However, the male risk of death is around four times that of females. (The lower ratio for people aged 65 years and over may reflect no more than the larger numbers of older females in the population). Also, the disproportionate number of male driver fatalities relative to females appears to peak for the ages 21-29; there is no such peak for injury crashes or for overall crash involvement.

A somewhat similar pattern emerges from UK data for 1988 (Department of Transport, 1989, p 69), shown in Table 7.

Table 7: Relative male:female risk (no allowance for exposure) for all road deaths (not just drivers) by age groups, UK, 1988 (Department of Transport, 1989).

Age group	All road deaths Male to female ratios
15-19	4.0
20-24	5.7
25-34	3.8
35-44	3.3
45-54	3.0
55-59	1.9
60-64	1.9
65+	1.0

Since these figures are for all road deaths, rather than just those of drivers, it is difficult to interpret the significance of the downward trend with age for the UK data which is not apparent in the New York data on driver deaths (apart from the figure for those aged 65 years).

Looking at UK data on drivers *injured* (see Table 8), the pattern is similar to that of New York in that the male:female ratio for injuries is much lower than for deaths. However, while the New York data are fairly constant across age groups, the UK pattern shows peaks for the youngest and oldest drivers.

New Zealand data for 1980-1987 (Jones and Frith, 1988) showed that for overall casualty rates (not just driver casualties), the ratio of males to females for those aged 15-19, 20-24 and 25-29 was about 2.3 . It gradually reduced from this high point to around 1 for those aged 70 years and over.

Australian data suggest that male:female ratios for young drivers are generally lower than elsewhere. Thus, data from South Australia for the years 1981-1988 (ORS, 1990) show that the ratio of male to female driver casualties (killed and injured) was about 1.5 for the 16-24 age group, 1.2 for people aged 25-59, and 1.9 for people 60

years and over. As for the New Zealand data, South Australian casualties include both deaths and injuries.

Table 8. Relative male:female driver injuries, by age groups, UK, 1988 (Department of Transport, 1989)

Age group	Drivers injured Male to female ratios
17-19	2.1
20-24	1.6
25-28	1.6
29-34	1.5
35-54	1.4
55-64	2.2
65+	2.7

Male:female driver ratios of crash involvement obtained from analyses of NSW data for 1990, conducted as part of the present project, are shown in Table 9.

Table 9. Relative male:female driver casualties, by age groups, NSW, 1990.

Age group	Drivers killed or injured Male to female ratios
17-25	1.3
26-40	1.2
41-55	1.3
56-98	1.4

Considering that the ratio is generally higher for deaths than for injuries, and that these NSW figures include both deaths and injuries (only 2%-3% were deaths), the values are low by comparison with both UK and New York injury crash male:female ratios. They may reflect differences in the relative numbers of licensed drivers in each of these age groups; without specific information on exposure it is impossible to interpret.

4.3.2 Trends over time in gender differences

Analyses of national USA databases (IIHS, 1991) showed that over the period 1980-90 the ratio of male to female deaths tended to decrease. Analysis of NSW data for the present project for the years 1986-1990 also showed a tendency for the ratio to decrease with time. It seems likely that this decrease may be associated with a relative increase in the exposure to risk of females.

Mayhew and Simpson (1990) reviewed recent Canadian crash data concerning the relative risk of male and female drivers. In general terms it appears that in Canada there has been a similar trend to that found in the USA and Australia: that is, male:female risk ratio has decreased during the 1980s, particularly for young drivers. It is likely that at least to some extent this decreasing ratio is due to a relative increase in the distances being driven by young females. (See Section 4.3.3 below).

4.3.3 Gender differences in exposure

Variation in results between different studies concerning male/female differences in crash rates may be related to differences in the quantity and quality of their exposure to crash risk.

For example, Williams (1985) reported data from the 1977 National Personal Transportation Survey for the USA showing that males consistently drove greater distances than females, and a greater percentage of male drivers' mileage was at night, across all age groups (see Figures 11 and 12).

Figure 11: Passenger vehicle miles driven per USA driver licence holder (from Williams, 1985, p 2).

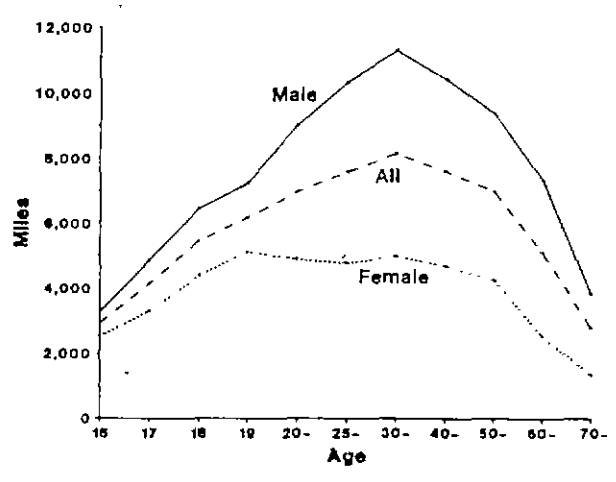
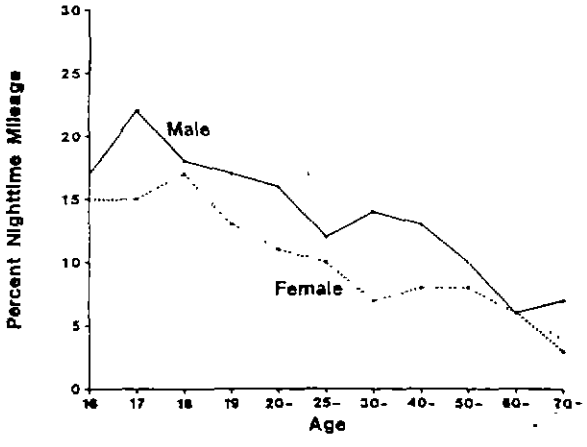


Figure 12: Percentage of passenger car miles driven by USA driver licence holders at night (from Williams, 1985, p 3).



Popkin (1989) noted that the USA National Personal Transportation Study (1987) showed an increase in female driving, and in female drink/driving. For example, females aged 21-24 years in late night single vehicle crashes had an alcohol involvement rate nearly as high as that of males. Consistent with this, the proportion of females in fatal crashes in the USA was found to be increasing.

However, distances driven by North American female drivers are still significantly lower than distances for males. Smiley (1990) found that in Ontario, females reported having driven approximately half the distance reported by men. Male/female differences for time spent driving were less than for distance driven, indicating slower driving speeds for females, possibly due to a lower proportion of their driving being on highways. Waller (1990) commented that the Ontario findings were similar to those of an earlier North Carolina study, and probably represent a general pattern, at least for North America.

Clearly, psycho-socio-economic differences between different cultures and countries are likely to be associated with the differences in the magnitude of male/female distances driven, and differences in the environments in which the driving takes place (eg day/night, freeways/other roads). The way in which such factors vary with age is also likely to differ in different locations. The importance of data on both the quantity and quality of exposure is again evident.

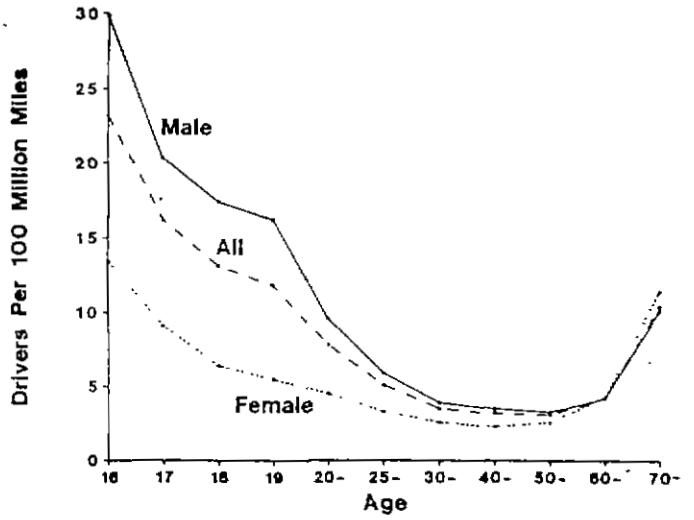
4.3.4 Gender differences in risk, allowing for exposure

Broughton (1988) analysed UK data for 1985 on crash involvement and casualty rates and found that whether or not there was a difference in rate between males and females depended on the type of road environment in which the crash occurred. Male and female rates per licensed driver were similar in built-up areas (maximum speed limit 40 mph) but male rates were higher in non-built-up areas (higher speed limits). There was a much stronger effect of time of day and day of week on crash risk for males than for females (see Section 4.4 below).

Broughton calculated injury and crash rates per 10^8 km for males and females for the following age groups: 17-20 years, 21-24 years, 39-43 years, 64-68 years, and 74+ years. The male rates for those aged 17-20 years were 2.4 and 3.2 times the average male rates, and the corresponding female rates were 2.0 and 2.4 times the average female rates. Between 1979 and 1985 rates generally fell, but some female rates rose. There was a much higher rate of single vehicle crashes for young males than young females, which Broughton suggested may be due to a difference in the nature of their exposure (time of day and type of road).

Williams (1985) reported USA fatal crash rates of drivers by age, sex and time of day, based on data from the 1977 National Personal Transportation Survey and FARS files. It was found that sixteen year olds, especially males, had by far the highest fatal crash rates per mile, both nighttime and daytime. Males had crash rates (per distance travelled) higher than females for all ages up to around the mid-50s, but the difference between males and females was very much larger for drivers aged 16 to 19. Above this age it reduced sharply down to about age 30 (see Figure 13).

Figure 13: Fatal crash rates per distance driven for males and females of different ages, USA, 1976-78 (from Williams, 1985, p 3).



Hauer (1988) showed (Figure 14) that in the USA in 1983 there was a large difference between male and female driver fatalities per licensed driver, the difference being largest for young drivers. However, the gender difference was reduced and for the oldest drivers was almost eliminated when the measure of crash risk was changed to driver fatalities per distance driven (see Figure 15).

Figure 14: Driver fatalities (all motorised vehicles) per million licensed drivers, USA, 1983 (from Hauer, 1988, p 195).

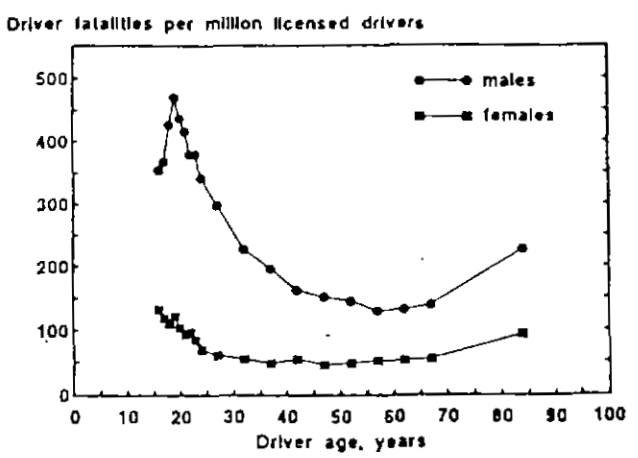
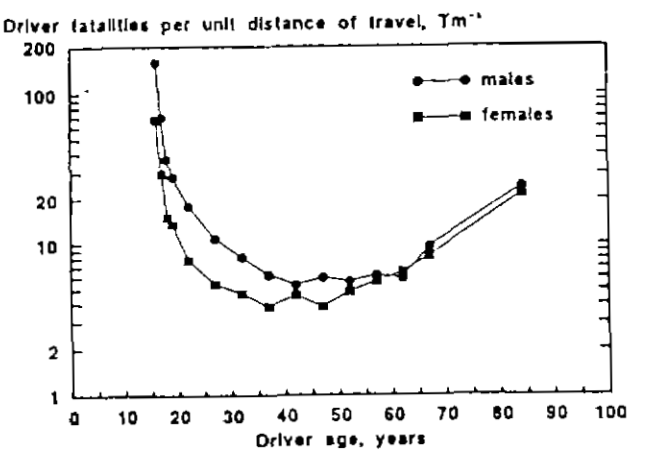


Figure 15: Driver fatalities (all motorised vehicles) per unit distance travelled, USA, 1983 (from Hauer, 1988, p 195).



Contrary to the above results, Harrington (1972) cited Californian data which showed that male and female teenagers had the same crash rates per distance driven. From Australia, Cave (1986) reported no gender effect on the relationship between crash risk and time since licensing when an adjustment for exposure was made. The data reported were obtained from a study carried out largely in 'built up' areas, where Broughton also found no significant gender difference among UK drivers.

Again, a factor to emerge from the above studies is the importance of controlling fully for exposure. Clearly, it is not sufficient to control only for distance driven: the time and place in which driving occurs also need to be considered.

4.3.5 Gender differences in driving behaviour

Male speeding

There is considerable evidence that an important factor underlying differences between male and female crashes is travel speed, and that this is particularly the case for young drivers.

A greater tendency for young males (and all males to a lesser extent) to drive at excessive speed might be suggested by Broughton's (1988) finding that UK male and female casualty rates per licensed driver were similar in built-up areas (maximum speed limit 40 mph), but male rates were much higher in non-built-up areas (higher speed limits). Alternatively, it may only indicate that males, particularly young ones, drive proportionately more often in higher speed zones. The finding that there was a much higher rate of single vehicle crashes for young males than young females, is consistent with either of these explanations.

Also consistent with either explanation is the Canadian finding of Cooper (1987) that in the age group 19-21 years, males were more likely to have had crashes at night, at higher speed, at mid block locations, and single vehicle run-off-road; there appeared to be a link between such occurrences and alcohol.

Male speeding is indicated by the results of Carsten, Tight, Southwell and Plows (1989), who investigated the possible causal factors associated with 1000 urban crashes in the UK on roads with speed limit of 40 mph or less. Males, particularly young males, were more associated with 'culpable' faults such as driving too fast, and females with 'mistake' faults such as lack of judgement. Overall, 42% of males and 36% of females were judged to have been 'at fault'.

Specifically, males (particularly young ones) had more frequently driven at an excessive speed, driven too fast for the situation, lost control (more often than females due to driving too fast or to personal impairment, less often than females due to situational problems or to skills errors), had 'manoeuvre problems', failed to stop, failed to anticipate (more often than females due to driving too fast, cognitive errors). Carsten et al (1989) commented that "This supports the ... belief that young male drivers are more prone to take risks" (p 48). A similar pattern of young male

behaviour was reported by Trankle, Gelau and Metker (1990): they concluded that young Swiss males were more likely than young females to commit violations related to inappropriate speed.

Female lack of skill

Females, on the other hand, appear more likely to be involved in crashes because of lack of skill. Thus, Carsten et al (1989) reported that they more frequently made judgement errors, failed to yield, (more often than males due to perceptual or cognitive factors) had 'situational' problems, made cognitive errors, and had no identified failure. Higher proportions of young females lost control of their vehicles "due to cognitive and skills errors" (p 49).

Consistent with this, Knapper (1985) reported that for young female drivers their fatality rate was highest at age 16 years when their inexperience was greatest. For males, however, there was no difference in fatality rate between the ages of 16 years and 19 years (Mayhew et al, 1981). Also, Cooper (1987) found that young females aged 16-18 years were particularly over-involved in crashes in which problems with vehicle control and turning manoeuvres had been a factor. Female novices also had more difficulties under adverse weather conditions. And Peck (1985) reported that while prior driver training was unrelated to crash rate in males, it was associated with a slight reduction in females.

Culpability

Williams and Karpf (1984) presented data from USA fatal crash data (FARS) from 1978. It was shown that for both males and females the youngest drivers (aged 16 and 17) had the highest probability of being responsible for the crash. This effect was greater for young males (up to about age 30-35) than for young females.

Consistent with this, Peck (1985) reported Californian data showing that male and female crash rates per distance driven were similar, but that males had more convictions per distance driven.

On the other hand, Lewis (1985) reported data from McDonald (1976) showing that for female drivers but not for males, amount of driving experience significantly distinguished culpable from non-culpable crash-involved drivers. Females with less experience were more likely to be culpable; this did not hold for males. However, Lewis suggested that the absence of a significant relationship for males might be due to the probable higher correlation between age and experience for males, which could mask experience effects.

Overall

The data obtainable from crash studies is of limited value in investigating differences in driving behaviour between different groups of drivers. This issue will be explored in more detail in a subsequent review of literature on driver behaviour. At this stage, it can be concluded from the crash literature that young male drivers are more likely

than young females to be involved in crashes due to excessive speed, while young female drivers appear to be involved more often than males due to inadequate driving skills.

4.4 Time of crash occurrence

It can be argued that time of day is a major determinant of the quality of drivers' exposure to risk. Specifically, there is evidence that driving at night is intrinsically riskier than driving in daylight (see Figures 16 and 17).

Figure 16: Fatal crash rates for male drivers of different ages per 100 million miles, for day and night separately, USA, 1977 (from Williams, 1985, p 4).

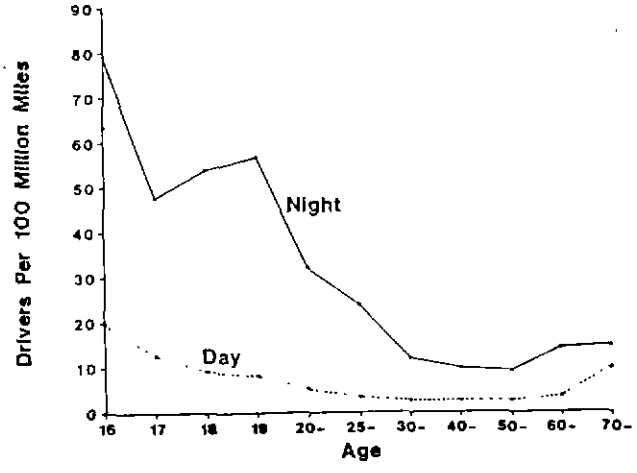
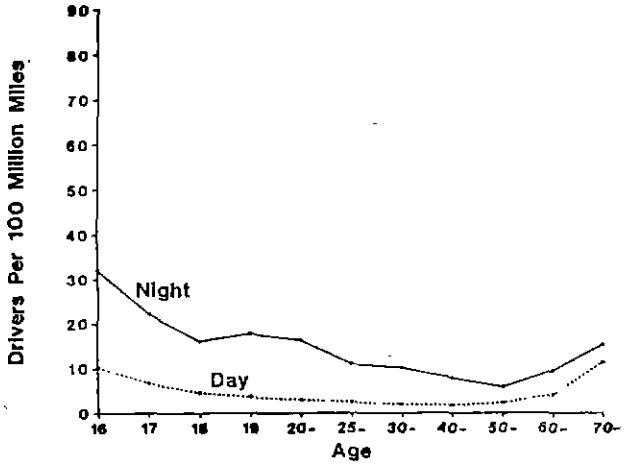


Figure 17: Fatal crash rates for female drivers of different ages per 100 million miles, for day and night separately, USA, 1977 (from Williams, 1985, p 4).



Presumably at least part of the cause is the degraded quality of visual information available to drivers at night, when crash rates per distance driven are higher for all drivers. There is also evidence that driving on weekend nights is riskier than on other nights, and it can be argued that at least part of the reason for this is because there are normally a higher proportion of drivers on weekend nights with excessive BAC levels, making such times riskier for other drivers (as well as for the high-BAC drivers themselves).

Section 4.4 considers evidence of variation in the crash risk of drivers of different age groups according to the time of day and day of week.

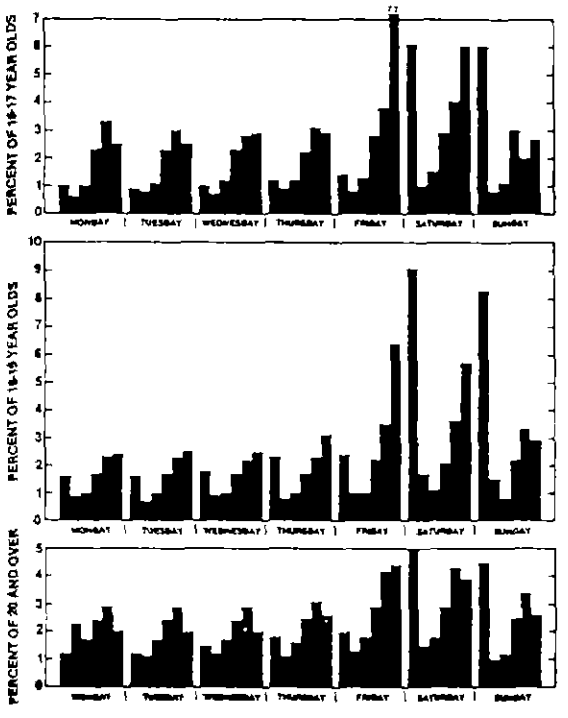
4.4.1 Time differences in risk, with no allowance for exposure

Robertson (1981) used data on fatal crashes from the USA (FARS, 1975-78) to explore the relationships between age of driver (16-17, 18-19, and 20 years or older),

gender, day of week, and four-hour periods within each day: data are shown in Figure 18.

It can be seen in Figure 18 that fatal crashes for teenagers were much more concentrated at nights, particularly weekend nights, than in the case of older drivers. However, this study did not take account of possible differences in exposure between different age groups which means that, as he pointed out, "this research could simply reflect the extent to which the identified groups were on the roads" (p 305).

Figure 18: Percentages of drivers in fatal crashes by age group, time of day and day of week, USA, 1977 (from Robertson, 1981, p 306).



Some more recent USA data (again unadjusted for exposure) on teenage road deaths in 1990 are shown in Tables 10, 11 and 12. From these it can be seen that:

- around half of 16-19 year old deaths occurred at night
- around 60% of teenage deaths occurred at the weekend (Friday to Sunday inclusive).

A similar pattern emerged from an analysis of South Australian data (ORS, 1990) in which three different age groups of driver: 16-24, 25-59, and 60 years and over, were compared. Drivers aged 16-24 had higher crash rates at nights and weekends, relative to older drivers. There were no data on exposure.

Tables 10, 11 and 12 are reproduced from "Fatality Facts 1991", IIHS, 1991.

Distribution of Teenage Motor Vehicle Deaths by Time of Day, 1990

	Percent
Midnight - 3 am	20
3 am - 6 am	8
6 am - 9 am	7
9 am - Noon	5
Noon - 3 pm	9
3 pm - 6 pm	14
6 pm - 9 pm	14
9 pm - Midnight	21

Percent of Teenage Deaths Occurring at Night (9pm - 6am), 1990

Age	Male	Female
13-15	34	37
16-17	49	45
18-19	60	51

Distribution of Teenage Motor Vehicle Deaths by Day of Week, 1990

	Percent
Sunday	19
Monday	10
Tuesday	10
Wednesday	10
Thursday	11
Friday	17
Saturday	23

Broughton (1988) found much the same pattern in the UK (see Figures 19 and 20). The data are shown separately for males and females, and it is apparent that the time effects, both time of day and day of week, were much less for females. Between midnight and 4 am, single vehicle crashes accounted for over half of driver casualties; young drivers, particularly males, were highly over-represented in such crashes.

Figure 19: Casualty rates per 1000 drivers by time of day, driver age and gender, UK, 1985 (from Broughton, 1988, p 17).

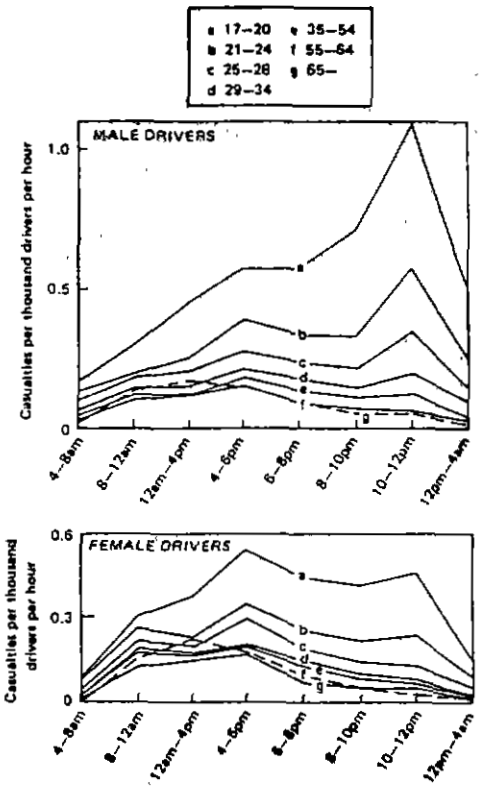
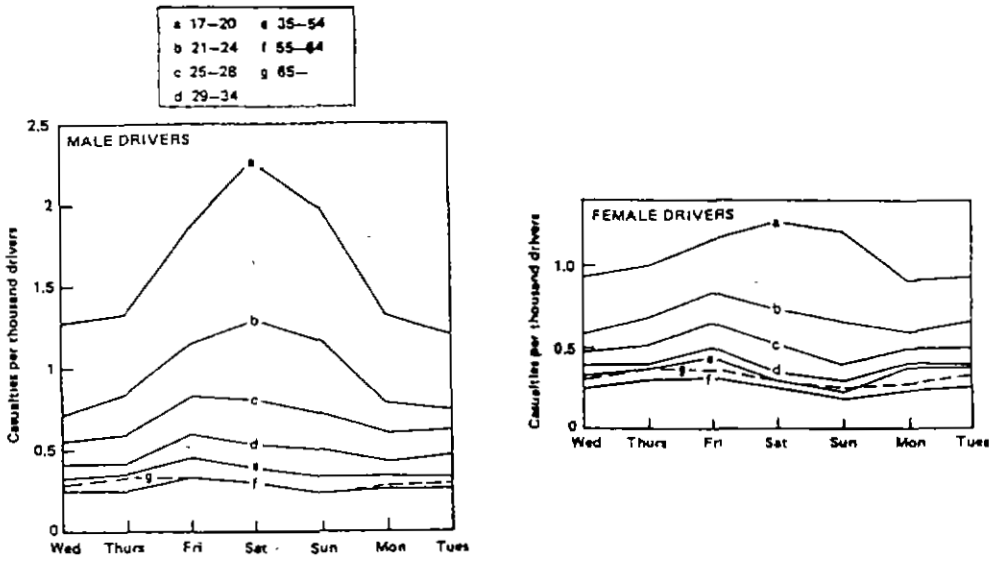


Figure 20: Casualty rates per 1000 drivers by day of week, driver age and gender, UK, 1985 (from Broughton, 1988, p 20).



Broughton found that young driver crashes tended to be more severe than those of older drivers, which he associated with a higher proportion of them being at night, when casualties are often fatal or serious, whereas older drivers are relatively more involved in daytime crashes, which include a higher proportion of less severe crashes. In 1985 about 44% of the crashes of male UK drivers aged 17-20 years occurred at night.

To describe the effect of these variables on crash severity, Broughton developed a mathematical model with terms for age effects, time of day effects and the total number of people injured, which calculates the expected severity of injury:

$$K(a,t) = C(a,t).A(a) + T(t)$$

where for drivers of age a involved in crashes at time of day t:

K(a,t) = number killed or seriously injured,
C(a,t) = number injured,
A(a) = effect of age,
T(t) = effect of time of day.

The model assumes that the pattern of variation in severity throughout the day is the same for all age groups, but allows each group to have a separate mean level. It was found to fit data from 1980 to 1985 very well, accounting for virtually all variation.

A report on Belgian young driver crashes (van den Meersschaut, 1989) pointed out that the over-representation of 18-24 year olds was greatest on weekend nights (10 pm-6 am), when they represented 43% of car drivers involved in serious crashes.

For Canada, Cooper (1987) analysed the age-related characteristics of injury crashes in British Columbia. Young drivers were defined as those aged 16-21 years. It was found that older drivers had 29.5% of their crashes at night, but young drivers had 37.6%; between 10 pm and am the figures were 14.8% for older drivers and 23.4% for young ones. Young drivers also had more of their crashes at weekends: 33.1% compared with 28.7% for older drivers. Overall, he found a higher than average involvement for young drivers in both urban and rural nighttime driving at weekends.

Like the preceding studies, this Canadian study did not control for the probable differences in exposure of different age groups at different times of day. Without exposure information, interpretation of results in terms of levels of risk of drivers on the road is not possible.

4.4.2 Time differences in risk, with some allowance for exposure

Chipman (1985) presented Canadian data showing that teenage drivers and those in their early 20s, particularly the latter, spent a larger proportion of their time driving at night.

Mayhew and Simpson (1990) presented data on the risk of nighttime death for drivers in Ontario and Saskatchewan aged 16-24 relative to those aged 25 and over. They used information on exposure obtained from roadside surveys. In Ontario young drivers' relative risk was 1.8 in 1979, and 2.0 in 1986; in Saskatchewan the figures were 1.4 in 1981 and 1.3 in 1987. It appears that variation over time within the same jurisdiction was much less than variation between jurisdictions. Reasons for a figure of 1.3 in Saskatchewan compared to a figure of 2.0 in Ontario were not discussed and are unclear. However, it may be relevant that in Saskatchewan drivers aged 16-24 represented close to half of all drivers on the road at night, whereas in Ontario they were around one third.

Williams (1985) used USA data from the 1977 and 1983 National Personal Transportation Surveys, files from the Fatal Accident Reporting System (FARS) and the National Accident Sampling System (NASS) to compute fatal crash rates of drivers by age, sex and time of day, taking account of distance driven. He found that while only 20% of teenager (16-19 year old) distance driven was at night (9 pm-6 am), 50% or more of their fatalities (both as drivers and passengers) were from crashes in this time period. Sixteen year olds, especially males, had the highest fatal crash rates per mile, both nighttime and daytime. Figures presenting mileage-based crash rates for day and night by driver age, for males and females separately, are shown in Figures 16 and 17, p 41 above.

Williams (1985) stated that teenagers were not more over involved at night relative to day compared with older drivers. "Despite their very high nighttime rates, teenagers,

including 16 year olds, are *not* more over involved in nighttime crashes relative to older drivers; in fact, the reverse is true with respect to older drivers through age 49. For example, the nighttime rate for 16 year old males is 3.3 times that of 25-29 year old males, but their daytime rate exceeds that of 25-29 year olds by a factor of 5.8." (Williams, 1985, p 3)

Drummond (1988) reported results of analyses of Victorian urban crash rates, determined on the basis of a roadside survey exposure study reported by Drummond and Healy (1986). Drivers were grouped according to time since licensing (<1 year, 1-2 years, 2-3 years, 3-5 years, 5-8 years, 8+ years) as well as by age. Nighttime driving showed casualty crash involvement rates for all driver groups which were higher at night than during the day; this effect was greatest for drivers with less than one year of experience.

These least experienced drivers had the largest increase in rate from day to night (in absolute terms: 1.01 compared with 0.34 for standard licence holders; in relative terms: 58% compared with 33%, 28% and 49% respectively for driving experience groups of 1-2 years, 2-3 years and 3+ years). There was no significant over-involvement of very inexperienced (less than one year of driving experience) drivers at weekends.

4.4.3 Overview of time effects

Again, it is clear that exposure to risk is a dominant factor determining variations in crash rates for drivers of different ages. In the studies which make no allowance for exposure, young drivers (particularly males) have very much higher crash rates at nights and weekends. However, when an attempt is made to allow for the proportion of time spent by different age groups driving at nights and at weekends, the pattern is much less clear cut.

The methods used to estimate exposure vary between different studies, and this may partly explain the differences in results obtained. Undifferentiated 'distance driven' data for different age groups is not sufficient; information on distance driven at different times is required, together with information on other aspects of exposure 'quality'.

4.5 Passenger characteristics

The presence of passengers, their characteristics and behaviour, may influence the driver's crash risk. Most obviously, passengers may distract the driver from the driving task. Such distractions might arguably be expected to increase crash risk more for young drivers than for older ones. Data from crash studies concerning young drivers' passengers is presented below.

Robertson (1981) found that in USA fatal crashes in the years 1975-78, drivers under 18 were more often accompanied by passengers than were older drivers. Passengers

of young drivers tended to be of similar age to the driver, particularly for males. More than 90% of male drivers under 18 years had no passengers aged 20 or older; for young female drivers the comparable figure was about 75%. There were no adult passengers in 83% of vehicles in fatal crashes where the driver was under 18. Generally, passengers tended to be of the same sex as drivers (see Table 13).

Table 13: Passenger deaths (percentages) in fatal crashes, by sex and age of passenger and sex and age of driver, USA, 1977 (from Robertson, 1981, p 312).

		Driver Age:	Less than 18					18–19					20 and Older				
Sex Driver	Sex of Passenger	Passenger Age:	0–13	14–15	16–17	18–19	20+	0–13	14–15	16–17	18–19	20+	0–13	14–15	16–17	18–19	20+
Male	Male	Percent Died:	29.5	29.8	31.4	33.8	39.7	34.7	29.8	31.8	34.0	37.8	19.4	18.9	24.6	30.2	34.5
		Number:	543	1758	3738	1360	811	326	637	2276	3785	2789	5098	1287	2246	3890	23837
Male	Female	Percent Died:	29.2	28.2	35 0	12.7	43.0	27.1	29.1	32.2	33.3	34.8	18.8	18.7	23.7	35.0	36.3
		Number:	281	969	1043	820	344	240	618	1285	1074	698	4248	960	1806	2119	23510
Female	Female	Percent Died:	30.7	26.0	29.8	29.6	44.6	33.3	29.1	27.9	31.1	40.6	23.6	16.5	19.5	27.5	41.2
		Number:	286	477	907	216	267	198	134	369	611	463	3713	552	518	586	6245
Female	Male	Percent Died:	29.4	20.8	27.1	21.2	36.9	26.8	16.7	20.6	27.6	27.9	22.7	15.3	17.7	21.9	37.5
		Number:	180	207	314	222	279	190	72	141	268	455	3483	392	265	288	4719

Williams and Karpf (1984) reported that teenage drivers in the USA were more likely to kill people other than themselves than were older drivers. People killed in road crashes who were aged over 21 were mostly the drivers themselves, but more than half the deaths from teenage crashes were passengers, or other driver/passengers. Williams and Karpf (1983) reported that in the USA in 1978, 63% of all fatally injured teenage passengers sustained their injuries in vehicles driven by teenage drivers, and 72% of the passengers fatally injured in vehicles driven by teenage drivers were teenagers.

O'Connor (1986) concluded from an analysis of 1986 South Australian crash data, together with a literature review, that both passenger occupancy and passenger casualty involvements were higher for young drivers, especially at night. Cave (1986) reported that Victorian drivers with two or more passengers had a higher crash rate at night, regardless of their level of driving experience.

Cooper (1987) found that young drivers (21 years and under) in crashes in British Columbia, Canada, were carrying more passengers than older drivers. Cooper interpreted this as suggesting a larger social element in driving for young people. The drivers of crash-involved vehicles with two or more passengers were less likely to be wearing a seatbelt than when there were fewer or no passengers.

Cooper provided a very detailed analysis of relationships between average numbers of passengers and their characteristics in relation to those of the driver, and details of the crash. For example, when young drivers were judged to have caused the crash they averaged 0.8 passengers per vehicle, as against 0.76 when they were not so judged. Young drivers to whom police assigned no contributing factors were carrying on

average 0.68 passengers, whereas those assigned 'unsafe speed' were carrying 1.07, those assigned 'alcohol' were carrying 1.10, and those assigned 'vehicle maintenance factors' were carrying 0.78. Number of passengers increased with lateness of the hour at night, and was higher at weekends than on weekdays. Many more such facts were reported.

Unfortunately, interpretation of this wealth of information is very limited without a corresponding set of facts related to drivers who were *not* involved in crashes: that is, without appropriate exposure data. This information was not provided.

There is little which can be concluded from available evidence on the possible role of passengers as causal factors in young driver crashes. Information is needed on the numbers and characteristics of passengers normally carried by drivers of different ages at different times and places. Without such information no conclusions can be drawn concerning the possible causal role of passengers in young driver crashes.

4.6 Crash type, pre-crash vehicle manoeuvres and driver errors

Material considered in this Section is concerned with information from mass databases and studies of crash occurrence about the nature of the crash: the vehicle movements and driver behaviour immediately preceding it.

Drummond and Torpey (1984) found that inexperienced Victorian drivers aged 18-20 years were involved in a greater proportion of single vehicle crashes than drivers aged 21-25 years. Approximately two thirds of the single vehicle crashes of 18 year old and first year drivers occurred at night.

Broughton (1988) analysed 1985 UK data. They compared injury and crash rates per 10^8 km for males and females for the following age groups: 17-20, 21-24, 39-43, 64-68, and 74 years and over. Single-vehicle crashes were particularly common among young drivers: more males aged 17-20 years were injured in 1985 in this type of crash than in any other type, and casualties of single vehicle crashes accounted for over half of all driver casualties between midnight and 4 am.

A report on young driver crashes in Belgium (van den Meersschaut, 1989) noted that young drivers are over-represented in run-off-road crashes in which the vehicle strikes an obstacle (post, tree, wall, ditch, safety barrier), probably caused by inappropriate speed. Such crashes tend to result in more severe injuries than average.

Peck (1985) concluded from an analysis of California data, supplemented by questionnaire and interview data, that excessive speed was by far the most common teenage violation, followed by equipment violations; for both these violations the teenage rate was higher than that of the general population

From an Austrian report (Hofner, 1989) it appears that young driver crashes in Austria typically involve overtaking and head-on collisions (particularly on curves), single

vehicle crashes (skidding and/or running off the road, collisions with fixed obstacles), and rear-end crashes. More of their crashes occur in bad weather.

Trankle, Gelau and Metker (1990) found from a review of German crash studies that young drivers were over represented in crashes resulting from inappropriate speed, loss of control, and negotiating curves. Speeding was cited as the most frequent cause of crashes involving 18-24 year olds, but not for older drivers. Ellinghaus and Schlag (1984) found that the crashes of West German drivers aged 18-24 years were due to loss of control (usually due to inappropriate speed) much more frequently (28.5%) than for middle-aged (16.9%) or older drivers (7.7%). Schlag (1987) found that young drivers tended to use inappropriate speed on curves. Knoflacher (1979) found a high incidence of cutting the curve in young driver crashes. Ellinghaus and Schlag (1984) found that crashes on curves accounted for 16% of all young driver crashes, whereas for older drivers percentages were all below 10%. Vertical inclines or declines were not frequently cited as crash locations, but the frequency of such crashes was higher for young drivers than for older drivers.

A report on South Australian crashes (ORS, 1990) compared drivers aged 16-24 years with those 25-59 years and those 60 years and older. Crash locations were classified into urban intersection, urban mid block, rural intersection and rural mid block. They reported that young drivers had relatively high rates of crashes mid block rather than at intersections, especially in rural areas. (Since percentages at each type of location were calculated *within* each age group, comparisons between age groups cannot be interpreted in terms of absolute differences in crash rates).

Within the young driver group, 16-18 year olds appeared to have more problems with vehicle control and turning manoeuvres, especially the females, who were the least experienced group. Female novices also had more difficulties under adverse weather conditions. Drivers in the 19-21 year age group, especially males, had more crashes at higher speed, at mid block locations, and in single vehicle run-off-road.

Driver errors were described in terms of the following six categories:

- Inattention (inattention, misjudgment, incorrect signal or sign, opening or closing door)
- 'Close' (following too close)
- Disobey convention (general failure to give way, fail to give way to right, fail to stand, fail to keep left, change lanes to endanger, incorrect turn, reversing without due care)
- Disobey signal/sign (disobey traffic lights, stop sign, give way sign, police signal, railway signal)
- Reckless driving (overtaking without due care, dangerous driving, excessive speed)

- Driving under the influence.

It was found that a high proportion of young driver crashes involved errors of 'reckless driving' and next highest was 'inattention'.

Cooper (1987) compared the characteristics of injury crashes involving young Canadian (British Columbia) drivers aged 16-21 years with those of older drivers. The only age-related difference in type of crash location concerned the speed zone: 19% of the older driver crashes were in zones with a limit higher than 60 km/h, compared with 16% for younger drivers. However, Cooper suggested that this probably reflected a difference in exposure.

Young drivers were more often judged by police to have caused the crash, possibly due to their higher percentage of single vehicle crashes. Within the young driver group, 16-18 year olds were more often 'at fault'. There was evidence of more 'risk-taking' by the younger drivers, in terms of speeding, driving 'without due care' and failure to wear a belt, but not in terms of following too closely. Belt non-wearing was linked to hazardous pre-collision actions, alcohol, poorly maintained vehicle, and greater number of passengers.

Crash-involved drivers aged 16-18 appeared to have more problems with vehicle control and turning manoeuvres, especially in the case of females (the least experienced group). Female novices also had more difficulties under adverse weather conditions. Crashes of drivers aged 19-21 years, especially those of males, often appeared to be linked to alcohol. These crashes were typically at night, at higher speed, at mid block locations, and single vehicle run-off-road.

Carsten et al (1989) conducted a very comprehensive and detailed analysis of 1000 urban crashes in North Leeds, UK The study was confined to crashes occurring on roads with speed limits of 40 mph or less. On average, 41% of drivers were considered to be 'at fault'. The percentage 'at fault' decreased with age through to 60 years, after which it increased to the youngest level.

Factors contributing to the crashes were coded at four different levels: top level immediate 'failures' (precipitating the crash), intermediate factors (neither precipitators nor behavioural), middle factors (behaviour or lack of skills leading to top level failures), and bottom level (explanations for middle or top level).

'Loss of control' and 'manoeuvre problems' were more common for younger drivers and for males. Loss of control over the vehicle (7% of top level) was most commonly explained by:

- driving too fast (27% - more common for younger drivers and for males)
- situational problems (19% - highest in females)
- impairment (14% - highest in 25-29 year olds and in males)

- skills error (9% - highest in females; there was some indication that young drivers lost control because of a skills error more often than older drivers)

- environmental factor (6% - eg slippery road).

'Failure to anticipate' was highest for drivers aged 20-24 years and for males. This top level failure was explained at the second level by:

- driving too fast (18% - highest in 25-29 year olds and in males)
- perceptual error (17% - highest in 14-24 year olds and in females)
- cognitive error (14% - highest in 14-19 year olds and in males)
- following too close (13% - lowest in 14-19 year olds and in those 60 years and over)
- situational problem (8%).

Among third level factors, 'cognitive error' was higher among females, and for the youngest and oldest groups; 'skills error' was uniformly low except for the 14-19 year old group.

Situational problems were explained at the third level by:

- unable to see (75%)
- environment factors (19%)
- obstruction/obscuration (4%).

There was little variation with age. It was thought likely that 'unable to see' factors were explained at a lower level by further obscuration factors.

Matthews and Jones (undated) investigated age-related changes in crash types for the most common two-car injury collisions in New Zealand (1975-1987 inclusive). They controlled for exposure by using a variation on the induced exposure index - the causation ratio: the ratio of the number of drivers in that age group primarily responsible for a given type of crash to the number in the group not responsible. Responsibility was assigned to only one of the two drivers, based on who failed to yield right of way, or on the basis of vehicle movements prior to the collision.

For the youngest drivers the most common crash types were lost control and head-on collisions. For all ages combined, the most common types of collision were: lost control on straights and curves (mainly single vehicle), and head-on, right-turn-against and crossing-no-turns (mainly multi-vehicle).

The authors categorised crashes as Type I or Type II, according to their age-related patterns of occurrence. Type I crashes were: head on, overtaking, lost control (curve and straight) and rear-end (hit vehicle in front). In these crashes the relationship between age and crash rate was in the form of a mirror-image J-curve; that is, the rate was very high for young drivers, and only increased slightly for old drivers.

Type 2 crashes were: crossing-no-turns, crossing-turns, right-turn-against, merging and manoeuvring. In these crashes the causation ratio increased with age: young drivers were relatively unlikely to have caused a Type II crash.

In summary, it can be concluded that the youngest and most inexperienced drivers (usually late teenagers) are involved in a greater proportion of single vehicle crashes than older drivers, particularly young male drivers at night. Such single-vehicle crashes typically involve running off the road, often due to excessive speed or 'reckless driving', and are more common in rural areas.

Other crash types in which some studies have found young drivers to be over-represented are head on, rear-end where the young driver was in the rear vehicle (Catchpole, Cairney and Macdonald, in press) and overtaking. However, there is conflicting evidence on the latter crash type: some studies have specifically noted that young drivers were *not* over-represented in crashes due to 'following too closely'.

Very young drivers appear to be involved in crashes due to poor vehicle control skills more often than in the case of older drivers, and are more often responsible for causing the crash. (The oldest drivers are also 'at fault' in a high proportion of their crashes).

Inattention or failure to anticipate was identified as a problem in the older group of young drivers (early 20s), especially males; this problem appears to be associated with perceptual and cognitive errors. Drivers in this age group also tend to have a high rate of alcohol involvement.

4.7 Alcohol and seatbelt offences

Driver BAC level and wearing of a seatbelt are both factors which are known to have major effects on crash risk. They are considered separately from other forms of driver errors and offences because, while clearly associated with driving they are not part of driving performance itself, and are therefore subject to different types of influence. The present focus is on relationships between driver age and these offences.

Alcohol offences

Table 14 shows percentages of USA 1990 driver fatalities for different age groups with blood alcohol levels (BACs) of 0.10 or higher (US Department of Transportation, 1991). It can be seen that the highest percentage of alcohol-related fatal crashes is in the 21-24 years age group; the youngest drivers (16-20 years) had a relatively low rate of alcohol involvement.

Consistent with the above, Peck (1985) found that in California the role of alcohol, as indexed by DUI convictions and identified by police among crash causes, was not a large factor in teenage crashes relative to those of other age groups. In South Australia (ORS, 1990) the findings were similar: young drivers were *not* over-represented in 'driving under the influence'.

Table 14. Percentages of drivers in fatal crashes with BAC level of 0.10>, USA 1990.

Driver age	%
16-20	21.2
21-24	34.7
25-44	30.3
45-64	15.6
65+	6.4

Results from Western Australia were reported by Baxter et al (1990). Figures derived from their data are shown in Table 15.

Table 15: Percentages of drivers in different age groups involved in fatal crashes in WA, 1989, with BAC levels of zero, and above the legal limit of 0.08

Driver age	BAC zero %	BAC 0.08+ %
17-20	60	28
21-24	55	28
25-29	58	33
30-39	78	13
40-49	75	22
50-59	87	13
60+	86	7

The comparable situation for New South Wales is presented in Table 16. It appears that the overall pattern is similar. Drivers in their 20s are those with the greatest percentage of alcohol-related fatal crashes; within this group, those in their early 20s appear to have the highest alcohol involvement, taking account of the percentages with zero BAC at the time of the crash.

Carsten et al (1989) found that 4.5% of drivers in a study of urban crashes in the UK reported having consumed alcohol in the three hours preceding the crash; 6% of these people considered the alcohol to have been a possible causal factor. The authors concluded that in loss of control crashes, driver impairment was a contributing factor in 14% of cases; the percentage was highest for drivers aged 25-29 years, and for males.

Cooper (1987) reported from in his British Columbia study that the youngest drivers were under-represented in alcohol offences. (The legal drinking age is 19 in British Columbia). However, crashes of drivers aged 19-21 years, especially those of males, often appeared to be linked to alcohol. These crashes were typically at night, at higher speed, at mid block locations, and single vehicle run-off-road. Cooper commented

that for both young and older drivers, drink-driving seemed to be a characteristic of a relatively small group of drivers having previous convictions for this and other offences.

Table 16: Percentages of drivers in different age groups involved in fatal crashes in NSW, 1990, with BAC levels of zero, and above the legal limit of 0.08

Driver Age	BAC Zero %	BAC 0.08+ %
17-20	58	31
21-25	41	39
26-29	49	34
30-39	50	35
40-49	52	35
50-59	61	14
60-69	75	7
70>	71	4

Cameron (1982, cited by Lewis, 1985) reported that most studies agree that drivers aged 16-19 years are *less* likely than older drivers to have been drinking prior to crash involvement, and young drivers who have consumed alcohol are likely to have lower blood alcohol levels (BACs); however, young drivers have an increased risk of involvement at low BACs relative to older drivers with the same BACs.

Other studies have confirmed this finding, especially the relatively higher crash risk for young drivers with low/moderate BAC levels (Williams, 1985; Simpson, 1985 cited by Romanowicz and Gebers, 1990). As BAC increases, relative risk of a fatal crash increases within each age group, but the increase is steeper for teenage drivers (Romanowicz and Gebers 1990).

Drink/driving is a behaviour open to influence by social factors which are likely to vary over time and between different communities. Popkin (1989) presented evidence that in the USA there have been recent increases both in the amount of female driving, and in female drink/drinking. While USA data over the preceding four years showed a general decrease in alcohol involvement in fatal crashes, there had been an increased incidence for crashes involving females aged 21-24 years, and females aged 21-24 years in late night single vehicle crashes had an alcohol involvement rate nearly as high as males.

Seatbelt offences

There is very little information on the relationship between driver age and seatbelt wearing in the context of crash occurrence.

Cooper (1987) reported that belt wearing rates in his Canadian study were 79.5% for young drivers and 85.7% for older ones. He noted that this age difference was consistent with data on previous driving convictions and crash-related charges, where

there was a higher rate of non-wearing seatbelt offences for young drivers. In the first 6-12 months post-licence there was a high belt wearing rate but it decreased markedly thereafter. As noted in the previous Section, belt non-wearing was linked to hazardous pre-collision actions, alcohol, poorly maintained vehicle, and greater number of passengers.

Baxter et al (1990) reported from an analysis of 1989 Western Australian crashes that seatbelt wearing rate was lowest (68.4%) for the male 27-31 age group. The average rate for seriously injured male drivers was 83.7%; the equivalent female rate was 93.2%.

5.0 OVERVIEW OF THE REPORT

The present report discussed some of the major conceptual issues underlying the young driver crash problem. A model of the determinants of young driver crash risk was proposed, according to which causal factors are categorised as those determining exposure to risk (external to the driver), and specific driver characteristics.

According to the model, driver characteristics are sub-divided into skill factors (underlying the 'young driver problem'), and motivation factors (underlying the 'young problem driver', in interaction with social factors). Exposure to crash risk is determined by quantitative factors (distance driven), and qualitative factors (nature of the environment, the road, vehicle and traffic conditions). Differences associated with driving at night versus driving during the day are seen to interact with many other variables within the model to affect crash risk.

Information on young driver crashes was reviewed in relation to each of the following variables: driver age, driver experience, driver gender, time of crash occurrence, passenger characteristics, crash type, pre-crash vehicle manoeuvres and driver errors, alcohol and seatbelt offences. These factors are significant elements within the theoretical framework, and information on them is available from mass databases and the research literature on young driver crashes.

Information was presented in terms of various measures: absolute numbers (of fatalities, of fatalities plus serious injuries, or of crashes involving fatalities and serious injuries); as rates (per head of population, or per licence holder) for fatalities, serious injuries, etc; and as rates per standard distance driven. Most of the data presented were for drivers, but some was for all people killed or injured in crashes.

It was evident throughout the discussion of information about crash rates and their patterns that interpretation of crash data is difficult or impossible without more extensive and detailed information on exposure to crash risk than is currently available. In view of the importance of determining not only the quantity but the quality of driver exposure, the methodological issues associated with estimating exposure demand increased attention from researchers.

5.1 Driver age

The relationship between driver age and crash occurrence is the central factor underlying the current research project. In general terms, young drivers are known to be over-involved in crashes. The extent and age-related pattern of young drivers' over-involvement varies somewhat in accord with the particular measure employed: crash involvement rates per head of population, per licensed driver, or per distance driven.

In terms of the first type of measure, the most common pattern is for drivers aged 18-24 to be at higher risk than older drivers. However, the pattern is by no means uniform, and it is evident that knowledge of numbers of casualties per head of population in different age groups is an unreliable index of the crash risk of young drivers actually on the road. When rates are calculated in terms of numbers of young drivers licensed, the general pattern of an increased risk for young drivers appears to be common to all jurisdictions where, as in Australia, young drivers have a significant level of exposure to crash risk.

However, calculated crash risk for young drivers relative to the numbers of young licensed drivers does not provide a satisfactory picture of relative risk between different age groups or places, because there is evidence that the quantity and quality of drivers' exposure to risk (distance driven, types of traffic environments) differs considerably between different age groups in different ways in different places. Unfortunately, there is relatively little information on young drivers' crash risk calculated to take account of their relative exposure to risk.

The conclusion from those studies which take account of distance driven was that crash risk is highest for young drivers, at a minimum for those in middle age, and rises again for very old drivers. It remains to be seen, however, how relative risk levels of drivers of different age groups might be changed if allowances were made for the quality of their exposure as well as its quantity.

5.2 Driver experience

In countries such as Australia, driver experience overlaps to a large extent with driver age, so the effects of these two factors are generally confounded, and there is relatively little information from which the effects of experience independent of age can be determined.

It was tentatively concluded that while both age and experience may be significant determinants of crash risk, age tends to predominate among young males. For older people, and probably for females, experience has a larger effect than for young males.

5.3 Driver gender

Mass crash data are commonly reported separately for males and females, with males typically being involved in more crashes than females. Such differences are at least partially explicable in terms of differences in distance driven, that is, the quantity of exposure, and psychosocial differences between the genders probably also affect the quality of their exposure to crash risk. There is some evidence that such gender differences have been decreasing in Australia, North America and the UK over recent years.

In terms of driving behaviour, there is evidence that young male drivers are more likely than young females to be involved in crashes due to excessive speed, while young female drivers appear to be involved more often than males due to inadequate driving skills.

5.4 Time of crash occurrence

It is clear that exposure to risk is again a dominant factor determining variations in crash rates at different times of the day and the week for drivers of different ages. In the studies which make no allowance for exposure, young drivers (particularly males) have very much higher crash rates at nights and weekends. However, when an attempt is made to allow for the proportion of time spent by different age groups driving at nights and at weekends, the pattern is much less clear cut.

The methods used to estimate exposure vary between different studies, and this may partly explain the differences in results obtained. Undifferentiated 'distance driven' data for different age groups is not sufficient; information on distance driven at different times is required, together with information on other aspects of exposure 'quality'.

5.5 Passenger characteristics

There is little which can be concluded from available evidence on the possible role of passengers as causal factors in young driver crashes. Information is needed on the numbers and characteristics of passengers normally carried by drivers of different ages at different times and places. Without such information no conclusions can be drawn concerning the causal role of passengers in young driver crashes.

5.6 Crash type, pre-crash vehicle manoeuvres and driver errors

The youngest and most inexperienced drivers (usually late teenagers) are involved in a greater proportion of single vehicle crashes than older drivers, particularly young male drivers at night. Such single-vehicle crashes typically involve running off the road, often due to excessive speed or 'reckless driving', and are more common in rural areas.

Other crash types in which some studies have found young drivers to be over-represented are head on, overtaking, and rear-end (young driver in rear vehicle). However, there is conflicting evidence on the latter crash type: some studies have specifically noted that young drivers were *not* over-represented in crashes due to 'following too closely'.

Very young drivers appear to be involved in crashes due to poor vehicle control skills more often than in the case of older drivers, and are more often responsible for causing the crash. (The oldest drivers are also 'at fault' in a high proportion of their crashes).

Inattention or failure to anticipate was identified as a problem in the older group of young drivers (early 20s), especially males; this problem appears to be associated with perceptual and cognitive errors. Drivers in this age group also tend to have a high rate of alcohol involvement.

5.7 Alcohol and seatbelt offences

The highest percentage of alcohol-related fatal crashes in Australia appear from available data to be in the 21-29 years age group; the youngest drivers (16-20 years) have a relatively low rate of alcohol involvement. This pattern is generally consistent with that in North America and the UK

There is very little information on the relationship between driver age and seatbelt wearing in the context of crash occurrence. There is some evidence that wearing rates are relatively low among young drivers (although not among the youngest drivers), and that non-wearing is associated with other non-driving behaviours which increase risk in some way (eg poor vehicle condition, excessive BAC, greater number of passengers).

5.8 The future

In a subsequent report, the nature of underlying causal processes will be examined by reviewing information on personal and behavioural characteristics of young drivers. Conclusions from the 'behavioural' literature will be related to those from the 'crash' literature reviewed in the present report.

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