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THE EFFECT OF VEHICLE ROADWORTHINESS ON CRASH INCIDENCE AND SEVERITY

by

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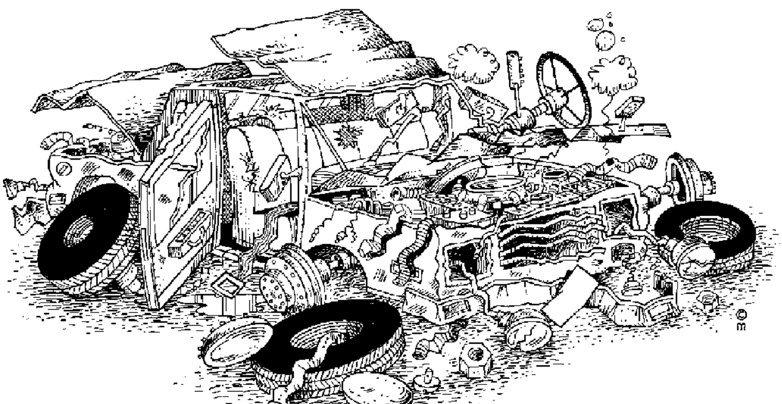

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The Effect of Vehicle Roadworthiness on Crash Incidence and Severity

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Abstract:

The Road Safety Committee of the Victorian Parliament is conducting an Inquiry into Vehicle Roadworthiness, and the effectiveness of vehicle roadworthiness systems in reducing the incidence and severity of crashes. This study is in response to a request by the Victorian Automobile Chamber of Commerce (VACC) to assist in their submission in responding to Question 1 of the Parliamentary Committee's Terms of Reference:

> "*The extent to which vehicle roadworthiness is involved as a primary or contributing factor in crash causation*".

The work presented in this report covers both passenger cars and motorcycles (but not trucks), and comprises:

- A literature review of Australian and international studies on the effects of vehicle defects, vehicle inspection systems, and ageing of cars.
- An analysis of the Coroner's Database (Victoria) for the period 1989-1998, to identify defective or unroadworthy vehicles and motorcycles that contributed to crashes.

Findings. There was significant variation in study findings regarding the role of vehicle defects in crash causation and the effectiveness of Periodic Motor Vehicle Inspections (PMVI) programs in reducing defects and crashes. Overall, it would appear that vehicle defects are a contributing factor in over 6% of crashes.

The effect of PMVI programs on accident rates as assessed by the studies varied significantly, from no effect to decreasing the accident rate by up to 16%. Few studies examined the effect of PMVI on the incidence of defects: a USA study found that it was associated with a 2.5% reduction; in Sweden, it was found that 7-8% of vehicles with serious defects were replaced after the introduction of PMVI. Some studies suggest that periodic roadworthiness tests could reduce the number of crashes caused by vehicle defects by about 50%.

Vehicle age was found to be an important factor. In Australia it was found that the odds of being involved in a fatal single vehicle crash were 2.5 times greater for a driver of a pre-1978 vehicle than a newer vehicle.

There are significant methodological and statistical difficulties and shortcomings in many of the studies, including the difficulty of identifying and detecting defects in crashed vehicles and their contribution to a crash. These problems would suggest an under-reporting of the contribution of defects to crashes.

From a safety viewpoint, it would appear axiomatic that vehicles need to be roadworthy and that this should be a prerequisite for their registration. What is really at issue is how this roadworthy condition can best be achieved and maintained.

Recommendations are made for further studies, including a comparison of defects found in the NSW and Victorian vehicle fleets.

Key Words:

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EXECUTIVE SUMMARY

The Road Safety Committee of the Victorian Parliament is conducting an Inquiry into Vehicle Roadworthiness and the effectiveness of vehicle roadworthiness systems in reducing the incidence and severity of crashes. This report was prepared to assist the Victorian Automobile Chamber of Commerce (VACC) in their submission to this Inquiry. The report focuses on responding to Question 1 of the Committee's Terms of Reference:

1. *The extent to which vehicle roadworthiness is involved as a primary or contributing factor in crash causation.*

The roadworthiness of both passenger cars and motorcycles is examined in this study. For the purposes of this study, a roadworthy vehicle is defined as one in which there exist no safety related defects at a particular time. That is, it would pass the applicable inspection scheme in the jurisdiction in which it is operated. The detection of defects and judgement about what classifies as a defect are, to some extent, relative concepts, rather than absolute ones, and can vary with vehicle model, age and time as components deteriorate or fail.

The work presented in this report comprises four main stages or activities.

- A literature review of Australian and international studies (and findings) on the effect of vehicle defects, vehicle inspection systems and ageing of cars.
- Analysis of the Victorian *Case-Control Study of Fatal Single-Vehicle Crashes* in regard to vehicle roadworthiness issues. This study includes information about 127 fatal single-vehicle crashes that occurred within 200 km of Melbourne during the 12-month period from 1 December 1995 to 30 November 1996.
- Analysis of the Victorian *Case-Control Study of Motorcycle Crashes* in regard to motorcycle roadworthiness. The cases in this study were 222 fatal and serious injury motorcycle crashes from late November 1995 to 30 January 1997.
- Analysis of the Coroner's Database (Victoria), for the period 1989-1998. Searching the text descriptions identified defective or unroadworthy vehicles and motorcycles that contributed to crashes. Of these cases 54 cases files were examined in detail.

FINDINGS

The effects of Periodic Motor Vehicle Inspection programs (PMVIs) on vehicle defects and crashes

In general, the prevalence of defects in the vehicle fleet has been found to be lower in jurisdictions with PMVI (up to 16%). Comparisons of inspected cars and non-inspected cars in the same jurisdictions suggest a drop in crash rates for the former. Studies that have compared crash rates before and after the introduction of PMVI have generally shown decreases in injury crash rates. However, some studies comparing jurisdictions have found no effect of PMVI.

Rompe and Seul (1985) noted that inspection programs may also influence and reduce crashes by increasing drivers' understanding of the need for regular maintenance, of safety issues and of the condition of their own car. These authors also note that their review of US studies suggests that periodic roadworthiness inspections could reduce the number of accidents caused by vehicle defects by about 50%.

Contribution of defects to crashes

Studies of crashed vehicles have shown that defects contribute directly or substantially from around 3% to 19%, with the more robust studies indicating at least 6%. Common defects identified relate to brakes and tyres. Many safety-related defects are found in crashed vehicles that did not contribute to the crash. There is some evidence that defects may contribute more to motorcycle crashes than to car crashes.

Vehicle age

Various studies have shown that older vehicles are over-represented in serious injury crashes. In Australia, Haworth et al. (1997a) determined the odds of being involved in a fatal single vehicle crash were 2.5 times greater for a driver of a pre-1978 vehicle than a newer vehicle. It is unclear in this study, and in many other studies that have examined vehicle age, to what extent this is due to some effect of deterioration with vehicle age versus improvements in crashworthiness of modern vehicles.

Methodological problems with the studies

There are methodological and statistical shortcomings in many of the studies. Defects are often under-reported and assessments of defects in crashed vehicles are difficult. The expertise and level of investigation are also factors affecting the determination of defects and their contribution to crashes. Measurements of the effects of inspection programs on crash rates have encountered difficulties in isolating the PMVI effects from those effects resulting from other major safety-related programs, other changes in vehicle fleets and differences between jurisdictions. These problems would suggest an under-reporting of the effects of defects on crashes.

ENSURING VEHICLE ROADWORTHINESS

Some vehicle defects clearly contribute to the occurrence of crashes. However, challenges exist in identifying systems that can adequately identify and reduce the occurrence of such defects. From a safety viewpoint, it would appear axiomatic that vehicles need to be roadworthy, and that this should be a prerequisite for their registration. What is really at issue is how this roadworthy condition can best be achieved and maintained.

1.0 INTRODUCTION

1.1 INQUIRY INTO VEHICLE ROADWORTHINESS

The Road Safety Committee of the Victorian Parliament is conducting an Inquiry into Vehicle Roadworthiness. This is aimed at considering and making recommendations on the effectiveness of vehicle roadworthiness systems in reducing the incidence and severity of crashes.

This study is in response to a request by Victorian Automobile Chamber of Commerce (VACC) to assist in their submission, in responding to Question 1 of the Parliamentary Committee's Terms of Reference[1]:

1. *The extent to which vehicle roadworthiness is involved as a primary or contributing factor in crash causation.*

The study focuses on roadworthiness for passenger vehicles and motorcycles, but does not include trucks (defined as goods vehicles over 3.5 tonne GVM).

1.2 DEFINITION OF ROADWORTHY

To interpret the research on the effects of roadworthiness on crash involvement and severity, it is helpful to have a clear definition of roadworthiness.

A roadworthy vehicle is one in which there exist no safety related defects at a particular time. The RACQ Submission to the Travelsafe Committee (1990) regards 'roadworthiness', as measured by the acquisition of a roadworthiness certificate, as an indication that the vehicle is safe to drive at the time that it was inspected.

The detection of defects, and judgement about what classifies as a defect, are very much relative concepts, rather than absolute ones. For example, vehicles vary from one make and model to another as regards their inherent primary safety and secondary safety performance, as well as their degradation with age. In one sense, a vehicle is roadworthy if it would pass a legal inspection in the jurisdiction in which it is operated. By this definition, the same vehicle could be roadworthy in one jurisdiction and not in another. Roadworthiness is not a constant attribute of the vehicle, either. A vehicle might be roadworthy today but not tomorrow if there is a failure of a component or components of the vehicle, for example, a signal lamp ceased to function. Defects may include some problems that are difficult to assess, such as a windscreen that distorts light.

1.3 METHOD

The work presented in this report comprises four main stages or activities. For each of these stages the central question to be addressed relates to providing information in response to Question 1 "The extent to which vehicle roadworthiness is involved as a primary or contributing factor in crash causation"

[1] Refer Appendix 1 for the full Terms of Reference for the Inquiry.

(i) **Literature review**. This comprises a review of Australian and international studies on the effect of vehicle defects on the incidence and severity of crashes, the effect of vehicle inspection systems on accident rates, the effect of ageing of cars and the contribution of vehicle defects to the severity of crashes.

(ii) **Analysis of the Victorian *Case-Control Study Of Fatal Single-Vehicle Crashes*** (Haworth, Vulcan, Bowland and Pronk, 1997a), in regard to vehicle roadworthiness issues. The study included information about 127 fatal single-vehicle crashes that occurred within a 200 km radius of Melbourne during the 12-month period from 1 December 1995 to 30 November 1996. The study provides two types of information relevant to crashworthiness and crash involvement:

- estimates of risk associated with the age of the vehicle, and
- inspection reports for vehicles involved in the crashes.

(iii) **Roadworthiness in the Motorcycle Case-Control Study.** This section presents some findings of the ***Case-control study of motorcycle crashes*** (Haworth, Smith, Brumen and Pronk, 1997b) relevant to motorcycle roadworthiness. The cases in the study were 222 motorcycle crashes occurring on public roads in the Melbourne metropolitan area from late November 1995 to 30 January 1997 in which the rider or pillion was taken to one of the participating hospitals or died. Three types of information collected in this study are relevant to motorcycle roadworthiness:

- estimation of the effect of age of the motorcycle on crash involvement,
- inspections of crashed motorcycles,
- judgements about the contribution of mechanical defects to crashes.

(iv) **Analysis of Coroner's Database (Victoria).** Another key source of information relating to the contribution to vehicle defects to crashes is the **Victorian Coroner's Database.** Two database searches were carried out**.**

1) The first search involved the Victorian Coroner's Facilitation System (CFS) currently held by MUARC, which spans the period July 1989 to June 1995. The CFS held by MUARC contains 9,238 records for the six-year period. Vehicles were defined as passenger cars, motorcycles, vans, utilities and minibuses (seats 8-20) and represented 3538 cases in the entire database. They were selected by using factor codes representing each vehicle type. Defective or unroadworthy vehicles contributing to crashes were identified by searching the text descriptions for each of the 3538 cases.

2) The second database search involved the Coroner's Database for the period 1989 to 1998, representing 4400 crash cases, and was undertaken by the Victorian Institute of Forensic Medicine, Research and Information Group. Of the 234 cases identified over the 10 year period, a subset of 54 cases were identified for the 3 year period from 1996 to 1998. These 54 cases were reviewed in detail by reading each case file at the coroner's office.

2.0 LITERATURE REVIEW - VEHICLE ROADWORTHINESS

This section of the report reviews the research literature and reports on the effect of vehicle inspection systems on accident rates, the effect of vehicle defects on the incidence and severity of crashes, and the causes of crashes. The effect of ageing cars is then covered, followed by a short section on the contribution of vehicle defects to the severity of crashes and a review of the role of driver awareness in relation to roadworthiness. A summary of the various studies and findings is presented.

2.1 THE EFFECT OF PERIODIC MOTOR VEHICLE INSPECTION (PMVI)

One method of determining the effect of roadworthiness on crash incidence is to examine the effect of periodic motor vehicle inspection (PMVI) programs on accident rates. The aim of PMVI is to eliminate defects from the vehicle fleet by inspecting all vehicles on a regular basis and ensuring that any detected defects are repaired before allowing the car to drive on public roads. If periodic inspection does reduce defects in the vehicle fleet, then studies that demonstrate that PMVI reduces crash rates may indicate that a reduction in vehicle defects is reducing crash rates.

It is important to note that PMVI may have other effects which cause the differences observed, such as promoting the number of newer vehicles on the road which may improve the crashworthiness of the vehicle fleet.

PMVI studies have primarily comprised of:

i) comparative studies between jurisdictions that do and do not have PMVI programs,

ii) 'before and after' studies of jurisdictions that have introduced PMVI programs,

iii) studies comparing the crash rates of vehicles that undergo PMVI with those vehicles that do not, within the same jurisdiction, and

iv) analyses of accident rates of inspected vehicles between periodic inspections.

2.1.1 Assumptions of the effectiveness of PMVI

One problem in examining the effect of PMVI on accident rates is that studies measuring its effectiveness assume that PMVI is effective in detecting and repairing all defects that may at some stage contribute to an accident.

An example of where this assumption may fail is demonstrated by Victorian rules relating to the detection of unroadworthy tyres. Tyres could run for a maximum of 10% of their lifetime below the legal tread depth in Victoria, that is, for about four months in a three year tyre life. Thus, the probability of detection of this defect in a yearly inspection program would only be 33% (Youngman and Stolinski, 1994).

In addition, inspection may not detect all problems. In a study in Pennsylvania in 1975, a car with 12 implanted defects was inspected at 20 different inspection stations (Carnegie-Mellon University, 1975, cited in Youngman and Stolinski, 1994). The average number of defects detected was four and the maximum was seven. On average, two non-existent defects were found. There was almost no relationship between the safety sensitivity of a defect and its likelihood of being diagnosed.

Many jurisdictions which have PMVI do not require inspection of all important safety components, and many licensed inspection stations do not conduct proper inspections of all the components they are required to by law (NHTSA, 1989). Also, repairs of inspected components that have been found to be defective have frequently not been properly conducted (NHTSA, 1989).

Studies that compare jurisdictions with and without PMVI often do not take any other differences between the states into account, such as the fact that states with PMVI may have safer roads due to more stringent motor vehicle policies.

2.1.2 Findings of studies comparing jurisdictions with and without PMVI programs

(1) Crain (1981) – USA

In a study by Crain (1981), accident rates for US states with PMVI were compared to states without PMVI.

The data, all from 1974, consisted of:

i) death rates (number of highway deaths per year per registered vehicle, obtained from the National Safety Council),

ii) injury rate (number of individuals injured per year per 1,000 vehicle miles, obtained from the US Federal Highway Administration), and

iii) accident rate (number of non-fatal accidents per year per 1,000 vehicle miles, obtained from the US Federal Highway Administration).

The independent variables included in the statistical equations included: the existence and nature of inspection programs, the procedure for drivers licence renewal, and minimum damage required for reporting an accident. In addition, in order to equalise the states on all measures, the following independent variables were incorporated into the statistical equations: population density, median family income, fuel consumption, extent of federal highways, the percentage of the population between 18 and 24 years of age, and alcohol consumption.

Statistical comparisons were undertaken on data from selected states. The comparisons included:

i) the accident rate of states with PMVI compared with those states with no PMVI (including those with random inspections),

ii) states requiring annual inspections compared with states requiring biannual inspections, and

iii) states employing random inspection procedures compared with those that employ compulsory periodic inspections and those with no inspection programs.

The results of the statistical analyses showed no statistically significant difference in accident and injury rates for states with PMVI compared to states without PMVI. There was no statistically significant difference in accident rates between states with biannual PMVI and states with annual PMVI. Crain (1981) has noted that '…..*vehicle inspection programs do not have the expected effect of reducing accident rates*' (p 29) and that '…..*more frequent inspections do not tend to reduce accident rates*' (p 32).

In addition, there were two unexpected findings of this study. The first was that there was a tendency for states with PMVI programs to have *higher* death rates than those without PMVI, although this was not a statistically significant difference. The second was that states that conduct random vehicle inspections were found to be those with the lowest accident rates.

Crain (1981) suggested two reasons as to why PMVI programs may have failed to reduce crash rates. Firstly, additional resources devoted to vehicle maintenance as a result of periodic inspection may not improve the inherent safety characteristics of the vehicle. Alternatively, additional expenditure induced by periodic inspection requirements do make the vehicle safer, but this potential for improved safety is dissipated by adjustments in driver behaviour.

(2) NHTSA (1989) – USA

In a National Highway Traffic Safety Administration (NHTSA) study (1989), data was analysed to determine whether PMVI was having an impact on reducing the crash rates of passenger cars.

Three series of analyses were carried out. The method for all three series involved analysing the crash rate proportion of old to new vehicles in each state and comparing the results for PMVI states with the results for non-PMVI states. The rationale for this is as follows. As vehicles age, the condition of components critical to safety deteriorate and therefore the likelihood of crash involvement as a result of mechanical failure increases. If PMVI is successful in maintaining the mechanical condition of cars, then there will be less difference in the crash involvement rates of old to new vehicles in PMVI states than in non-PMVI states. Differences just in the crash involvement rate of newer cars in PMVI states as compared to non-PMVI states may discount the effects of PMVI, as new cars would have not been in service long enough for significant wear of mechanical components to occur.

Of all the states in the USA, 22 had PMVI and 29 did not at the time of this study.

Three main data sources were used in the NHTSA analyses:

(i) **Fatal data**. This was obtained through the Fatal Accident Research System (FARS). This is a census of all fatal motor vehicle crashes in the US occurring on a public roadway in which a death occurs within 30 days of the crash. A limitation of FARS data is that it only contains data for fatal crashes, which make up less than 1% of all crashes. The advantage of this data is that it is available for all states within the US, so valuable comparisons between the states can be made.

(ii) **State accident data**. State accident file data, obtained from each US state, was also used. Limitations of this data include the fact that only a small number of states were included, and that there may be differences in accident reporting styles between states. The advantage is that this data includes all types of accidents. This data was used for 10 states; four PMVI states and six non-PMVI states.

(iii) **Component failure data.** CARDfile data (Crash Avoidance Research Data) supplied information on component failure. This data identifies vehicles coded by police officers as having a component failure that was suspected of contributing to the crash, as well as coding for all other causes of crashes. Thus, the proportion of vehicles believed to have a component failure contributing to the crash can be identified. Component failures that were identified were categorised into defective brakes, defective steering, defective or improper lights, worn or defective tyres and all other defects.

The author has commented on two factors that may be influencing the data. Firstly, 19 out of the 29 non-PMVI states conduct random inspections of passenger vehicles. Secondly, within the PMVI states there is considerable variation in the equipment items inspected and the procedures, rules and regulations for inspections.

NHTSA Series One Analysis

Two comparisons were carried out as part of the first series of analyses. In both comparisons, the crash involvement rates of cars of varying ages in PMVI states were compared to the crash involvement rates of cars of corresponding ages in non-PMVI states.

(i) **First comparison.** The first comparison was between crash rates of cars ranging from one year to three years old over a single 12 month crash period between July 1 1985 and June 30 1986. FARS and state accident data were used for this comparison.

The FARS data showed that fatal crash rates are higher in PMVI states for some model years and lower for others. There is no clear indication that crash involvement rates across vehicle model years are consistently different in non-PMVI, compared to PMVI states. The author has noted that '*These results do not suggest a PMVI effect on the fatal crash involvement rate*' (p 41).

The state accident data showed that the overall accident rate was always higher in states without PMVI, regardless of the age of the vehicle (a 10% difference overall). The fact that this finding was for vehicles of all ages makes the analysis of the effectiveness of PMVI confusing. If PMVI was having an effect, then there should be no difference in the crash rates of new cars in PMVI states as compared to non-PMVI as they would not yet have had a chance to deteriorate and therefore be able to benefit from inspections. These findings give '…...*no evidence .... that PMVI programs affect the crash involvement rates of older vehicles compared to newer vehicles*' (p 44).

(ii) **Second comparison (series one).** The second comparison was for crash rates of 1975 model year cars over the years 1976 to 1986, using the FARS data.

It was found that there was a decrease in the relative fatal crash rates as vehicles aged for both PMVI and non-PMVI states. There was no difference between PMVI and non-PMVI states for an older car to have a crash. Thus, there '…..*is no trend supportive of a PMVI effect*' (p 43).

NHTSA Series Two Analysis

A second series of analyses used CARDfile from 1984 to 1986 for four states. Almost 600,000 passenger cars were examined from Maryland and Washington, which are non-PMVI states, and over 1.5 million passenger cars were examined from Pennsylvania and Texas, which are PMVI states. Only passenger cars 10 years or younger were included in the analysis.

The proportion of crashed vehicles with a component failure that was reported to have contributed to the crash was found to be significantly greater in states without PMVI for cars of all ages using CARDfile (see NHTSA Series Three Analysis following for an analysis by defect type). This difference ranged from less than 0.25% to a 2.5% difference, depending on the age of the car. Older cars experienced a greater difference.

In a follow up analysis, vehicle component failures reported by police in fatal crashes were analysed using FARS data from 1985 to 1987. It was found that the proportion of vehicles involved in a fatal crash with defects reported as having contributed to the crash is consistently higher in non-PMVI states than in PMVI states, in similar figures to the previous analysis. There was a non-statistically significant tendency for this difference to be greater the older the vehicles. This finding supports that of the CARDfile analysis. In addition, this data applies to all states and so extends the scope of the finding.

The fact the proportion of older crashed vehicles with a component failure that was reported to have contributed to the crash was found to be greater in states without PMVI supports the notion that the difference is due to inspections. However, the author has noted that '*......the differences in defects reported in relatively new vehicles between non-PMVI and PMVI states were most likely due to factors other than the presence or absence of a PMVI program*' (p 48).

NHTSA Series Three Analysis

Using CARDfile, an analysis by defect type was undertaken.

Tyre failures were found to be significantly more common (up to 2.5%) in non-PMVI states for almost all vehicle ages, possibly indicating a PMVI effect. However, again, '*....the fact that non-PMVI states reported a significantly higher percentage of component failures in relatively new cars suggests that factors other than the presence or absence of PMVI may account for the difference in component failures reported*' (p 50).

2.1.3 Studies comparing jurisdictions before and after the introduction of PMVI

(1) Asander (1992) – Sweden

Asander (1992) has summarised statistical reports published by AB Svensk Bilprovning, the Swedish motor-vehicle inspection company, since the introduction of PMVI in Sweden in 1965.

The article by Asander (1992) indicates that the introduction of compulsory PMVI in Sweden has resulted in a vehicle fleet with less defects than before its introduction. A reduction in the most serious defects in the vehicle fleet was the first change made after the introduction of compulsory PMVI. In 1965, 7-8% of vehicles were replaced due to serious defects. The vehicle fleet continued to grow despite the elimination of many vehicles due to serious defects, as scrapped cars were quickly replaced with new ones.

Two reasons for the reduction of defects in the vehicle fleet have been suggested by Asander (1992). Firstly, car owners were made more aware of the condition of their own vehicles and chose to replace them in order to pass inspections. Secondly, motorists felt that it was not worthwhile to repair the defects identified at an inspection, and scrapped the vehicles.

In addition, between 1964 and 1966, the years immediately preceding and following the introduction of compulsory PMVI, police reported accidents with personal injury decreased by 16%. 1964 was Sweden's worst road safety year so far.

Asander (1992) has noted that these changes occurred three years before the change over to right hand drive, an oft quoted catalyst of change in trends of traffic in Sweden.

(2) Berg, Danielsson and Junghard (1984) – Sweden

Berg, Danielsson and Junghard (1984, cited in Fosser, 1992) used a time-series analysis to examine Swedish crash data from 1955 to 1981. They found that following the introduction of annual inspections in Sweden in 1965, the number of cars involved in police reported accidents declined by 14% and the number of injury accidents declined by 15%.

(3) Loeb and Gilad (1984) – USA

Loeb and Gilad (1984) investigated the effect of PMVI in reducing fatalities, injuries and accidents in New Jersey. This study analysed time series data for the years 1929 to 1979, which includes data from both before and after the introduction of compulsory PMVI to New Jersey in 1938.

Injury, fatality and accident data was obtained from a variety of sources, including Government departments. Other independent variables included various measures of driving (such as maximum highway speed) and population. Again, data for these variables was accessed from a number of sources. Dummy variables were also incorporated into equations in order to account for factors such as the effect of inspections, the effect of the world wars on driving and for technological changes over time.

Regression analyses were carried out separately for accident rates, fatality rates and injury rates using the data outlined above.

The results indicate that the presence of PMVI statistically significantly reduced the number of highway fatalities (by just over 300 per year) and accidents (by almost 38,000 per year) in New Jersey. No significant effect of PMVI on reducing injuries was found.

Loeb and Gilad (1984) have suggested two reasons to account for the effect of PMVI on fatalities and accidents but not on injuries. Firstly, inspections may detect major safety defects but not minor ones. Secondly, inspection may play a role in changing the attitudes of drivers such that they fix major safety defects.

The authors have commented that there were problems with data collection for this study. Notably, data was missing for a number of variables and had to be estimated.

(4) Little (1971) – USA

A study by Little (1971) examined the effect of PMVI on traffic death rates. Data, consisting of death rates and numbers of deaths, were obtained through the National Safety Council.

Death rates in different groups of US states were compared over the time period between the end of WWII and 1961.

The groups that were compared were:

i) states which began inspection programs between the end of WWII and 1961 (test group),

ii) states which did not begin inspection programs at all (non-inspecting control states),

iii) states with programs that had been well established before the end of WWII (inspecting control states), and

iv) the whole USA.

Control states were matched as closely as possible with test states on population size and geographic considerations.

The results of statistical analyses of the data indicate that the increase in death rates over time in test states was over 5% *higher* than that of either control state (all groups experienced some increase in death rates over time). There was no statistical difference in crash rates between inspecting and non-inspecting control groups over time. There was no statistically significant difference in the increase in death rates between test states and the nation as a whole.

There was some variation in results within each group studied. For example, some test states experienced an increase in death rates following the introduction of PMVI, and some experienced a decrease in death rates over the same period of time.

The study concludes that '*Certainly, no sensible person is likely to argue that inspecting cars makes them more susceptible to fatal accidents. On the other hand, the data seem to invalidate arguments that current periodic vehicle inspection programs account for differences in death rates in any given year between inspecting states and non-inspecting states.'*

However, the authors then go on to say that '…..*the most reasonable conclusion may be that something more fundamental than inspection is at work in producing and changing death rates*' (p 306). For instance, factors such as differences in economic development and vehicle growth between states during the post-war period are likely to override the effects of PMVI on fatality rates. Overall, the authors point out that the use of changes in death rate may not be a useful measure of the effectiveness of PMVI.

2.1.4 Studies comparing the accident rates of inspected and non-inspected cars, in the same jurisdiction.

(1) Fosser (1992) – Norway

Fosser (1992) reported an experimental evaluation of the effects of periodic motor vehicle inspection on accident rates. The study asked the following questions:

i) Does periodic motor vehicle inspection reduce the risk of becoming involved in road accidents for vehicles that undergo such inspection?

ii) If periodic motor vehicle inspection reduces the risk of becoming involved in accidents, what is the best estimate of the size of the effect?

iii) Does the effect of periodic motor vehicle inspection vary according to the age of the car? How long does the effect last?

iv) Does the effect of periodic motor vehicle inspection vary according to the frequency of inspections?

v) Does periodic motor vehicle inspection affect the severity of accidents?

vi) Does periodic motor vehicle inspection prolong the service life of cars?

The study population was cars registered in Norway for the first time in 1978, 1979 and 1980. These years were chosen so that the cars would be old enough to have developed technical defects, but not too old as to be likely to be scrapped during the experiment. The cars in the study population were randomly assigned to one of three groups:

Group 1. Cars inspected in 1986, 1987 and 1988,
Group 2. Cars inspected in 1986 only, and
Group 3. Cars not inspected (the control group).

The accident experience of each car was monitored for three one-year periods following technical inspection. The control group was assigned fictitious inspection dates based on the known inspection dates of the cars in the other groups.

The number of accidents per 1,000 car-days did not differ significantly among the three groups in any of the three accident periods. The results indicate that neither annual inspection, nor inspection every third year, had any effect on the accident rate of the cars included in the study.

The authors caution that there are a number of factors that should be considered in the interpretation of the results. The experiment was conducted in Norway, where there is a high level of random roadside inspection (about 20% of vehicles per year) and this may be enough incentive for owners to prevent their vehicles being defective such that periodic inspections have no additional effect.

In addition, the age of the cars in this study was deliberately restricted to between approximately seven and eleven years. It may be that periodic inspections have a beneficial effect for vehicles older than 11 years. It should be noted that these vehicles make up less of the vehicle fleet because of scrappage and therefore the potential benefits are limited.

(2) Schroer and Peyton (1979) – USA

Schroer and Peyton (1979) compared the accident rate of vehicles that participated in a Motor Vehicle Diagnostic Inspection Demonstration Program (or ‘Auto Check’) in Alabama with vehicles which did not actively participate. The program involved the setting up of a number of diagnostic inspection stations around the state of Alabama in order to determine whether it was cost effective to set up such stations. Inspection was not mandatory and drivers learnt of the program through advertisements. An inspection involved checking 106 items on each vehicle. Some motorists returned for various reasons including for a repair, for an inspection after a repair or for a standard periodic inspection.

Data used in the analysis consisted of the Auto Check inspection files, the Madison County motor vehicle registration files and the Alabama Department of Public Safety accident files. A sample of cars from urban areas from 1968 to 1973 model years was selected that had undergone a first periodic inspection between April 1975 and December 1976. The Auto Check sample comprised almost 8,500 vehicles and the non-Auto Check sample comprised over 30,000 vehicles.

The adjusted accident rate for inspected vehicles was 9.1% lower than that for the uninspected vehicles for the first year after inspection.

Included in the sample of drivers who underwent inspections, was a subsample of drivers who returned for subsequent periodic inspections (responsive participants). This group experienced a 21% improvement over the accident rate of drivers in the uninspected vehicle group. The monthly accident rate of those who returned for subsequent inspections did not increase. The monthly accident rate of those who did not return for subsequent inspections increased to the level of uninspected vehicles over an eighteen month period.

In a follow up investigation into accident rates of vehicles before inspection it was found that the accident rate of inspected vehicles decreased at least 5.3% after inspection.

The inspection reject rates for the brake, steering suspension and the wheel alignment systems for Auto Check vehicles involved in accidents were compared to the reject rates for the non-accident vehicles. On average, those vehicles involved in accidents were in worse mechanical condition than those that were not involved in accidents, for every critical system.

The results of this study suggest that poor mechanical condition is a factor that contributes to motor vehicle crashes. The influence of self-selection on the results cannot be ruled out, though, as subjects for the study were all volunteers.

2.1.5 Study examining accident rates between inspections

(1) White (1986a) – New Zealand

White (1986a) examined the accident rate of New Zealand vehicles in relation to the time since their most recent inspection. The New Zealand vehicle inspection system was compulsory and biannual.

Data consisted of written records from testing stations from over 21,000 inspections of private cars, as well as Traffic Accident Report data from the New Zealand Ministry of Transport. A thirteen month period was chosen for analysis as this was just over twice the official inter-inspection period.

An analysis of the data indicates that the probability of accident involvement increases with time since last inspection. Accident rates were lowest one week after inspection, and then increased by 10-15% over the next six months until a peak one week before the next inspection. White (1986a) has concluded that '*....mandatory safety inspection has an immediate safety benefit which decreases over time*' (p 51).

This result suggests that vehicle defects do contribute to accidents, but that periodic inspection may not be the best method to *maintain* roadworthiness.

Again, the author has noted that the data was not of ideal quality as it was obtained from one area of New Zealand and was therefore not representative of the whole country.

2.1.6 Summary of information regarding PMVI studies

The results of above studies suggest that PMVI improves the condition of vehicles on the road. Whether or not this has an impact on reducing accident rates has not been clearly established.

2.2 STUDIES EXAMINING CAUSES OF CRASHES (THE CONTRIBUTION OF DEFECTS)

Examining the causes of all accidents that occur within a given time and place is one useful method of determining the contribution of defects to crashes. There are, however, problems associated with these studies.

2.2.1 Problems associated with studies examining the causes of crashes

(1) Under-reporting of defects in crash data

One major problem is that often defects are under-reported as the cause of crashes, resulting in a lack of reliable crash data on the contribution of vehicle defects to crashes (Vaughan, 1993).

Police frequently prepare initial crash reports. Often, the police do not have the time, equipment or qualifications to detect any but the most obvious defects (NHTSA, 1989; Vaughan, 1992). This then further reinforces the view that defects do not cause accidents. Thus, police will be less inclined to look for them.

In addition, police reports may not provide comprehensive data in that a standard report form consists of boxes to tick, which may be limiting in terms of the scope of the information that can be included. Campell (1981) has suggested that narrative description of an accident by a police officer is a much more useful tool in determining the true cause of an accident.

Another reason why defects may be under-reported is because defects that have caused an accident may be undiagnosable (for example, a vapour lock in the footbrake), unrecognised (for example, drowsiness induced by carbon monoxide poisoning), not tested or simply not reported (White, 1986b).

The problem is further complicated by the fact that crashes are often caused by more than one factor. It is often difficult to identify all causes of crashes (Asander, 1992; Gardner, 1995; Vaughan, 1992, 1993). Therefore, if driver error or poor road conditions were involved, worn brakes or tyres, for example, may not be recognised and therefore, not reported.

The proposition that defects are under-reported is supported by the findings of Vaughan (1993) which show that brakes that are out of adjustment often do not appear in police reports, despite this being the most common serious problem found in the inspection of vehicles at inspection stations. Tyre faults account from a half to two-thirds of the defects reported in police reports, when in-depth crash studies often find tyre problems to be one quarter to one-sixth less frequent than brake problems.

Further support that standard accident reports are not comprehensive is evident in Vaughan (1993). This study noted that '*where in-depth crash studies have investigated vehicle factors in the crash causal chain, the more detailed the study (and the greater the level of expertise of the investigators), the greater the proportion of crashes identified where vehicle factors have played a causal role*' (p128).

(2) Misreporting of defects in crash data

Mis-reporting may be another reporting problem. Poor vehicle design as well as defects may contribute to accidents, and may both be classified as 'vehicle faults' in reports.

2.2.2 Contribution of defects to crashes

(1) McLean et al. (1979) – Australia

The Adelaide In-depth Study (Part 4, McLean, Brewer, Hall, Sandow and Tamblyn, 1979; Part 6, McLean, Aust, Brewer and Sandow, 1979) was a large scale observational study. A sample of accidents to which an ambulance was called in the Adelaide metropolitan area was investigated at the scene by a multi-disciplinary team from the Road Accident Research Unit of the University of Adelaide over a 12 month period from March 1976. Each accident was investigated by an engineer, a psychologist and a medical officer. Their observations began on average 10 minutes after the ambulance was called and were supplemented by further investigations including interviews with people involved in the accidents, detailed examination of the accident site, observation of uninterrupted traffic behaviour at the same time of day as the accident, and inspection of crashed vehicles at towing sites.

8% of all accidents (304 accidents) were observed. This sample was representative of the accident population by time of day and day of the week.

68 motorcycle accidents involving 69 motorcycles were investigated. 12 motorcycles were found to be defective, but in only one case was the defect considered to be relevant in the causation of the crash. The types of defects found were worn tyres (4), one or both rear vision mirrors missing (4), brake light not working (3), and rear brake faulty (1). The defect that appeared to have played a role in causing the accident was a brake light not working (the switch was disconnected). This accident occurred at night. In about half the cases, the motorcycle was so badly damaged that it could not be ascertained whether there were any defects.

Of 386 cars examined, 11 were found to have defects regarded as significant causal factors and three in which the defect was definitely the major factor in the causation of the accident. Tyres were the most common defects detected. When inspecting cars, no attempt was made to dismantle the car. This may have resulted in an underestimate of the incidence of defects in the braking system being identified. However, it is believed that those accidents in which defects played a role were identified due to an assessment made of the brakes and other systems based on the general circumstances of the accident.

The results of these studies indicate that in only a small proportion of accidents do vehicle defects play a role in causing crashes.

(2) Duignan, Williams and Griffiths (1996) – Australia

In a NSW paper, Duignan, Williams and Griffiths (1996) presented preliminary methodology of an in-depth study, to be published June 1999. This study has been investigating the presence of defects and their role in crash causation and severity, using 5,000 vehicles from all vehicle categories. Comprehensive on-scene and follow up examination has been undertaken of all vehicles involved in a crash. These examinations are conducted to specified guidelines in order to provide a consistent and objective approach to data recording and analysis. All major and minor vehicle faults are examined and wherever possible, measured. Faults will be analysed in terms of vehicle category, rural versus urban, and component areas (eg. steering, brakes).

Preliminary results are not yet available (personal communication, P. Duignan, April 1999).

(3) Grandel (1985) – Germany

DEKRA (the German Motor Vehicle Inspection Association) annually analyses the technical defects found during inspection of vehicles after accidents with regard to their accident causing potential. Each accident vehicle, and usually each accident site, is examined as soon as possible after a crash. Examinations are conducted by an engineer who has been specially trained to detect defects in crashed vehicles. Details on the causes of accidents are collected, in addition to standard accident data. All accidents in which someone is killed or injured, or property has been severely damaged are required to be reported and examined under German law.

Grandel (1985) presents a collective analysis describing which vehicle components are considered to be the causes of accidents, using the DEKRA data. The results of the study indicate that 6.5% of passenger cars and 5% of two-wheeled vehicles (including motorbikes, mopeds and motorised bicycles) involved in crashes had defects that may have contributed to the crash. Defects in brake components and tyres were the defects that most commonly contributed to accidents.

Over half of the vehicles inspected had defects, yet only the small percentages mentioned above were cases in which defects contributed to crashes.

(4) Masuri, Sasaki and Urano (1982) – Japan

Statistics suggest that 1.3% of accidents in Japan are attributable to a defect in the vehicle (Rompe and Seul, 1985). In Japan, drivers are expected to examine their own cars every day, and follow up with a more thorough (usually professional) check monthly, or six-monthly (Masui, Sasaki and Urano, 1982).

(5) Treat (1977) – USA

From August 1972 to June 1977 an in-depth study of car accidents in Monroe County, Indiana, was carried out by personnel from the Institute for Research in Public Safety (IRPS). This study was conducted independently from the police. Investigations were carried out immediately after a crash. Drivers were interviewed at the accident scene, physical evidence was collected, and the vehicles were inspected briefly. The technicians also made clinical assessments of the causes of the accident. *'Cause' was defined as '....a deficiency but for which an accident would not have occurred'* (p 393). Of over 2,000 accidents investigated, a subset of 420 of these crashes were investigated in greater depth by a multidisciplinary team of professionals. Sample selection for this section was based on the willingness of subjects to participate. These vehicles were inspected by an automotive engineer at the IRPS inspection facilities.

After analysing the results of the in-depth component of the study *'....vehicular factors were identified as causes in 4.5% to 12.6% of the accidents investigated....[the range] indicating definitive and probable results respectively....'* (p 394). The on-site teams reported similar findings. They found that vehicle factors contributed to between 4.1% to 9.1% of crashes.

Different causes may have overlapped such that vehicle and environmental and driver factors may have all contributed to causing the crash simultaneously. Treat has calculated that *'Overall, human factors were identified as probable causes in more than 95% of the accidents investigated, compared to 34% for environmental factors and about 13% for vehicular factors'* (p 403).

The most frequently implicated categories of defects that had caused accidents were the braking system (2.9% to 5.2%), tyres and wheels (0.5% to 4%), communication systems such as lights and glazed surfaces (0.2% to 1.7%), steering systems (0.2% to 1%) and body and doors (0.5% to 0.7%).

(6) Haworth, Vulcan, Bowland and Pronk (1997) – Australia

Haworth et at. (1997) conducted a case controlled study of fatal single vehicle crashes in Victoria from December 1995 to November 1996 (see Section 3 for details of this study). Of all the crashed cars, 37% had defects that rendered them unroadworthy. However, it was found that mechanical defects contributed to 3% of crashes. Tyre and brake problems were the most common defects.

(7) Haworth, Smith, Brumen and Pronk (1997) - Australia

Haworth et al. (1997) conducted a case controlled study of motorcycle crashes in the Melbourne metropolitan area from November 1995 to January 1997 (see Section 4 for details of this study). It was found that mechanical faults contributed to about 12% of crashes overall. The authors noted that the proportion was much higher for single vehicle crashes, being 28%. The incidence of defects contributing to multi-vehicle crashes was 7%.

(8) Other Literature reviews

There have been a number of previous reviews of the literature in the area of the effect of roadworthiness on crash incidence. The findings of these reviews are mixed. Some conclude that roadworthiness of vehicles does reduce crash rates, others that it has no effect.

From their reviews of the literature, many researchers have concluded that vehicle defects directly contribute to under 10% of all accidents (Asander, 1992; Crain, 1981; Forest and Youngman, 1991; Gardner, 1995; Report of the Queensland Travelsafe Committe, 1990; White, 1988; Youngman and Stolinski, 1994). In one review of the literature, Rompe and Seul (1985) found that several in-depth studies have concluded that vehicle defects have directly or substantially contributed to between about 3-24% of all crashes. In regard to the effectiveness of PMVI programs, they note that (p9) '..the most accurate and cautious US surveys suggest that periodic roadworthiness tests could reduce the number of accidents caused by vehicle defects by about 50%.".

In another review, Gardner (1995) found that many studies examining the role of defects in crashes vary in their results. Gardner (1995) has suggested that this may be due to the fact that accidents may be caused by more than one factor, and it may be difficult to determine the true causes of crashes.

Reviewers have concluded that different types of defects are responsible for crash causation. Vaughan (1992) found that in Sweden braking, structural and steering defects are identified as the most common defects, but that tyre faults are identified as defects in half to two thirds of Australian crash data. Brake problems were found to be common defects in Australian data also (Forest and Youngman, 1991; Vaughan 1992).

Vaughan (1993) has found that in-depth studies consistently find that brakes comprise the largest source of vehicle defects that cause crashes. Design and manufacture of brakes has improved, but poor maintenance may still cause problems.

2.3 STUDIES EXAMINING THE EFFECT OF THE AGE OF CARS INVOLVED IN CRASHES

Vehicle age is an important factor when examining the effect of roadworthiness on crash rate. Vehicles are known to decrease in both roadworthiness and safety over time. This is due to two factors;

i) deterioration of vehicle components, and

ii) safety features built into newer vehicles that are not present in older vehicles, making the newer vehicles safer.

In Australia, older cars form an increasing proportion of the vehicle fleet (McIntosh, 1998; Vaughan, 1992; Youngman and Stolinski, 1994). It is therefore likely that the average level of defects in the Australian vehicle fleet has been increasing and will continue to increase. If defects contribute to crashes as seen in the previous section, then it is possible that the increased level of defects in older cars will mean that these cars will have more accidents.

(1) Vaughan (1992) – Australia

Vaughan (1992) analysed NSW crash data from 1977 to 1991 (inclusive) in which occupants of passenger cars were killed. It was found that '*The occupant death rate per 100 million kilometres of travel in older cars has ......consistently been the highest in the car age categories*' (p 51).

This trend is true of other countries also, including the USA (NHTSA, 1989), Germany (Grandel, 1985), and Sweden (AB Svensk Bilprovning, 1992, cited in Vaughan, 1992).

Vaughan (1992) has postulated that some roadworthiness factors contribute to the higher rate of accidents in older cars including the fact that older vehicles may be in poorer conditions than newer cars. Other factors have also been suggested by Vaughan as contributing, such as the fact that older cars provide lower levels of occupant protection than do newer cars due to design advances, and that the types of people driving older cars (for example, younger people) may differ from those driving newer cars (Youngman and Stolinski, 1994).

(2) Motoring Directions (1998) – Australia

Contributions from independent road safety experts, representatives of federal and state road and transport authorities, motoring organisations and the automotive manufacturing and retail industries were presented in an article in Motoring Directions (1998).

The article noted that older vehicles are over-represented in crashes where deaths and serious injuries occur. In a pre-1970 model year vehicle the risk of being injured in an accident is double that for a 1990 model year vehicle.

The Motoring Directions article (1998) focused on the positive effect of newer cars being fitted with improved safety features as the reason why older cars have a higher accident rate, rather than the contribution of defects in older cars.

(3) McIntosh (1998) – Australia

In an Australian Automobile Association report, McIntosh (1998) has outlined the improved design for vehicles in Australia, focusing on these improvements as the main contributing factor in the increase in occupant protection offered by newer cars. The major safety benefit in new cars outlined is the inclusion of airbags.

(4) Jacobson (1982) – England

The question remains; do older vehicles have more defects than newer vehicles, and do these defects contribute to accidents? There is little reliable data to quantify the number of older or badly maintained cars that are at risk from latent defects (Jacobson, 1982).

Jacobson (1982) has noted that there is '*…..a progressive deterioration with age and mileage of steering, suspension and brakes*' (p 947). Tyres were also noted as deteriorating with age. Due to driver factors, deterioration of older cars does not necessarily contribute to the incidence of accidents in the majority of cases. Jacobson (1982) has commented that 'Under normal operating conditions most drivers can and do compensate for the progressive deterioration of clutch, brakes, wear in steering linkages, even the partial collapse of hydraulic dampers. Only in emergency accidents avoidance manoeuvres is it likely to cause serious problems' (p 924).

One reason older cars may experience increased severity in case of an accident is that the rust degradation of the vehicle body results in a decreased level of occupant protection. The majority of injury accidents are frontal collisions (Jacobson, 1982). Jacobson (1982) has reported on frontal crash tests on heavily corroded cars at one of Europe's best Auto Safety Centres. The tests (in accordance with Society of Automotive Engineers guidelines) were conducted on two heavily corroded, eight year old cars. Both cars were fully driveable prior to the crash test, and had been in regular use in New York. The exact makes and models of the cars tested in this study were not mentioned.

There was no corrosion of the front seat belt anchorage points, and they were found to be satisfactory in the crash test for both cars. In terms of occupant protection, the results showed that '*Even in its severely rusted state, the 8 year old saloon car gave occupant protection, which compares well with current motor cars of other manufacture*' (p 945). This car may have been a particularly good model, though, as it was found to be '*superior to many European cars in their factory new state manufactured and tested around 1972/74*' (p 945). However, it was found that there was little structural resilience left in the corroded sections of the older cars. The conclusion reached by Jacobson (1982) is that it is important to ensure that new car design incorporates effective in occupant protection which will endure as the vehicles age.

(5) Treat (1977) - USA

A study by Treat (1977 – refer Section 2.2) found that older cars were over involved in accidents in which a mechanical problem was implicated. Treat noted *'The probability of an accident-involved vehicle eight years or older being cited for a causative vehicular problem was more than two times greater than for accident-involved vehicles in general'* (p 398).

2.4 EFFECT OF VEHICLE DEFECTS ON INJURY SEVERITY

Very few studies have examined the effect of vehicle defects on the severity of injury in case of an accident. Reference is made to this issue in some wider studies. Some of these studies have found that defects do exacerbate the extent of injuries to occupants of the cars. This is particularly true of older vehicles. Injuries due to defects may be as a result of deterioration of body or engine parts, such as faulty steering resulting in the driver not being able to control the car once an accident has occurred. The fact that older cars do not have the same safety features, such as airbags, that are built into younger cars, is also considered to be a vehicle fault.

From the results of one study that was examining the effect of PMVI on accident rates, Loeb and Gilad (1984, see section 1.2.3) have suggested that inspections may detect major safety defects but not minor ones, resulting in more serious injuries in case of a crash.

Vaughan (1992) and Rompe and Seul (1985) found that older cars provide lower levels of occupant protection than do newer cars, and the occupants are more likely to be killed if involved in crashes. Reasons for this include deterioration, and also improved safety features of newer vehicles.

However, Jacobson (1982, see section 4.1.4) found that, at least in some models of cars, age deterioration will not necessarily contribute to more severe crashes.

2.5 THE ROLE OF DRIVER AWARENESS OF SAFETY ISSUES IN RELATION TO DEFECTS

2.5.1 The role of random inspections

A theme that is repeated through many of the studies is that random inspection may be more effective in reducing crash rates than PMVI, or is vital as a supplement to periodic inspections. The reason put forth in various studies was that random inspection encourages motorists to maintain their cars in a roadworthy condition at all times, whereas PMVI encourages motorists to maintain their vehicles in a roadworthy condition only at inspection times (eg. Asander, 1992; Crain, 1981).

It is widely accepted that the human element comprises the largest influence on the occurrence of an accident, followed by the environment, followed by the mechanical condition of the car (eg. Asander, 1992; Forest and Youngman, 1991; Gardner, 1995; RACQ, 1990).

Gardner (1995) has suggested that promotion of the need to maintain a vehicle in a safe condition and the owners responsibility for this is likely to have more road safety benefits than any form of periodic or change of ownership inspection systems. The owners accountability in this area can be reinforced by random inspections that target individual groups or classes of vehicles where there are likely to be some safety benefits.

Youngman and Stolinski (1994) and Forest and Youngman (1991) have noted the advantage of a random inspection system by comparing Victoria to NSW. The Victorian system consists of random roadside inspections by police and compulsory inspections at change of ownership. The NSW system has comprised compulsory periodic inspection for many years. In 1992 the NSW accident rate was about 50% higher per kilometer traveled than in Victoria (Youngman and Stolinski, 1994). However, it is important to note that many other factors influence differences between the states.

Schroer and Peyton (1979, see section 2.1.4) found that those drivers who self-selected for inspection had less accidents than other drivers. The authors have suggested that this may have been as a result of their heightened awareness of safety issues rather than the inherent safety of their vehicles. Also in this study, the accident rate of vehicles that did not return for repeat inspections reached the same level as uninspected vehicles, suggesting that drivers who did not take responsibility for their own cars had vehicles with more defects that then contributed to accidents.

This point is further supported by White (1986a, see section 2.5.1). The results of this study suggest that vehicle defects play a role in crash causation, but that periodic inspection may not be the most effective way of maintaining a defect-free vehicle fleet as the condition of vehicles appeared to deteriorate from the time of one inspection until the next one. White (1986a) has suggested that drivers did not take responsibility for the roadworthiness of their vehicles, but rather left it up to the inspections.

One shortcoming of random roadside inspections is that there are technical limitations to an inspection by the road, and thus not all defects may be detected (Asander, 1992).

Asander (1992) has commented that any PMVI program needs to be supplemented by random roadside inspections otherwise it is possible to neglect the vehicle all other times and concentrate all service and maintenance to the inspection period. This article concludes that the two types of inspections should supplement each other, not replace each other.

2.5.2 Increasing driver awareness of their own vehicles

Rompe and Seul (1985) commented that the awareness of the driver is important in preventing accidents. They have noted the systems in Germany and Sweden require the driver of the car to stay with their vehicle for the duration of the inspection. This increases the drivers understanding of the need for regular maintenance, safety issues and the condition of their own car.

2.6 SUMMARY OF LITERATURE REVIEW

Table 2.1 presents a summary of the principal findings of this literature review.

Table 2.1 Summary of findings from articles included in the literature review

Studies examining the effect of inspection programs			
Study	**Country**	**Findings in brief**	**Implications of findings**
Duignan et al. (1996)	Australia	No results yet.	No results yet.
Fosser (1992)	Norway	There was no difference in the crash rate between cars that undergo PMVI and those that do not, in the same jurisdiction.	No difference in accident rate associated with PMVI. However significant level of random testing also occurs.
Asander (1992)	Sweden	There were less defects in the vehicle fleet (7-8% cars with serious defects scrapped), and a 16% decrease in road injury following the introduction of PMVI to Sweden.	PMVI associated with a decrease in the number of defects in the vehicle fleet. PMVI is associated with a decrease the injury rate.

Table 2.1 Summary of findings from articles included in the literature review (cont.)

Studies examining the effect of inspection programs			
Study	**Country**	**Findings in brief**	**Implications of findings**
NHTSA (1989)	USA	No difference in fatality rates between states with and without PMVI. Overall crash rate was higher in states without PMVI. This was true for older and newer vehicles. Crashed cars with defects reported as the contributing cause to the accident were higher in states without PMVI.	PMVI is associated with a reduction in the accident (but not fatality) rate, but factors other than PMVI may be affecting the accident rates. PMVI associated with a decrease in the incidence of defects in the vehicle fleet.
White (1986a)	New Zealand	The probability of having an accident is lowest immediately following an inspection, and then increases until the next inspection (10-15% if inspections are biannual).	The probability of having an accident decreases immediately after an inspection, then increases until the next inspection.
Berg et al. (1984, cited in Fosser, 1992)	Sweden	The number of cars in police reported accidents and the number of injury accidents declined after the introduction of PMVI.	The introduction of PMVI is associated with a decrease in accident and injury rates.
Loeb & Gilad (1984)	USA	PMVI reduces fatality rates (around 300 a year) and accident rates (around 38,000 a year), but not injury rates.	PMVI is associated with a reduction in fatalities and accidents, but not injuries.
Crain (1981)	USA	States with PMVI experienced higher accident rates than states without PMVI (not statistically significant). States with random inspections experienced the lowest accident rates.	Random inspections are associated with a decrease in accident rate.
Schroer & Peyton (1979)	USA	Inspected cars had 9.1% fewer accidents than uninspected cars for the first year after inspection. Those who returned for inspections at periodic intervals experienced 21% fewer accidents than those who had never had an inspection, and those that did not return approached the same accident rate as those who had never been inspected.	The probability of having an accident decreases immediately after an inspection, then increases until the next inspection.
Little (1971)	USA	States that introduced PMVI experienced a 5% greater increase in accident rates over time than those that had no PMVI, or those that had well-established PMVI.	Study concluded that other factors must be influencing death rates, and that it could not be seriously argued that vehicle inspections could be associated with increased death rates.

Table 2.1 Summary of findings from articles included in the literature review (cont.)

Studies examining the contribution of defects to crashes			
Study	**Country**	**Findings in brief**	**Implications of findings**
Vaughan (1993)	Australia	Brake defects have been found to cause accidents.	Vehicle defects can cause crashes.
Grandel (1985)	Germany	In 6.4% of passenger vehicle crashes, and 5% of two-wheeled vehicle crashes, defects may have contributed.	A small proportion of crashes are caused by vehicle defects.
McLean et al. (1979)	Australia	12 out of 68 crashed motorcycles were found to have defects. One was considered as definitely contributing to the crash. 11 out of 386 cars were found to have defects. Three were considered as definitely contributing to the crash.	A small proportion of crashes are caused by vehicle defects.
Treat (1977)	USA	Of all crashes studied in-depth, 4.5% had defects that definitely played a role in causing the crash, and 12.6% had defects that probably played a role in causing the crash.	Vehicle defects can contribute to causing crashes.
Haworth et al. (1997) (single vehicle crashes)	Victoria, Australia	3% of crashes were caused by mechanical defects. 37% of crashed vehicles unroadworthy.	Defects may cause crashes in some cases.
Haworth et al. (1997) (motorcycle crashes)	Victoria, Australia	Mechanical faults contributed to 12% of crashes overall. Mechanical faults contributed to 28% of single vehicle crashes, and 7% of multi-vehicle crashes.	Defects may cause crashes. Mechanical faults may result in more single vehicle motorcycle crashes than multi-vehicle crashes.

Table 2.1 Summary of findings from articles included in the literature review (cont.)

Vehicle age and crashes			
Study	**Country**	**Findings in brief**	**Implications of findings**
Motoring Directions (1998)	Australia	Older cars are in more crashes than younger cars.	Older cars are more likely to crash.
Vaughan (1992)	Australia	Older cars are in more crashes than younger cars.	Older cars are more likely to crash.
Jacobson (1982)	England	Driver compensation may result in no increase in non-emergency accident rate in older cars. Crash tests of two corroded cars revealed little structural resilience in corroded sections of the car body.	Older cars are not necessarily at higher risk of non-emergency accidents. Corroded vehicle bodies offer little structural resilience.
Treat (1977)	USA	Cars older than eight years were twice as likely to crash as a result of vehicle factors than for all cars	Older cars are more likely to crash as a result of vehicle defects

From Table 2.1, it can been seen that results are quite varied. One reason why there may be variation in the results may be that methodological and statistical shortcomings are evident in many of the studies. This is noted by reviewers (eg NHTSA, 1989; Wolfe & O'Day, 1985) as well as authors of individual papers about their own studies (eg Loeb and Gilad, 1984; Schroer and Peyton, 1979; White, 1986a).

Another reason for the variation in the results may be due to other factors that affect different jurisdictions such as differing levels of other traffic safety measures, or different driving environments. These may not have been accounted for in the analyses of the various studies.

Also, differences in the fleet or wrecks available for study will have an impact on the data that can be obtained for a particular jurisdiction (Rompe and Seul, 1985). This makes comparisons of studies difficult.

Another major problem in determining the effect of defects on accident causation is that there appear to be no studies that deal directly with this issue. The most direct studies appear to be White (1986a, see section 1.3) and Shroer and Peyton (1979, see section 2.1.4). These studies indicate that that there is a reduction in accident rate following an inspection, but that the risk of having an accident continually increases until the next inspection. Assuming that inspection detects and repairs at least some of the accident causing defects involved in crashes, these results appear to indicate that defects do contribute to accidents. They also suggest that periodic inspections only solve part of this problem.

2.6.1 Summary of numerical findings of the studies

The following tables provide a summary of change in accident rate as a result of PMVI, the effect of PMVI on vehicle defects and the proportions of crashed vehicles with defects that either played a significant causal role or a contributory role in the accident.

Table 2.2 Percentage reduction in accident rates following the introduction of PMVI, or between jurisdictions with PMVI and those without

Study	Percentage reduction
NHTSA (1989) USA	**10%** (in accident rate) **0%** (in fatal crash rate)
Asander (1992) Sweden	**16%** (in accidents with personal injury)
Berg et al. (1984) Sweden	**14%** (in police reported accidents) **15%** (in injury accidents)
Romp & Seul (1985)	**50%** (in accident rate; figure cited in Romp & Seul based on USA studies)
Little (1971) USA	**-5%** (in death rates)
Fosser (1992) Norway	**0%** (Norway has a significant random inspection program)
Schroer & Peyton (1979) USA	**9.1%** (in accident rate, after one inspection, compared to uninspected vehicles) **21%** (in accident rate, after periodic inspections, compared to uninspected vehicles) **5.3%** (in accident rate for inspected vehicles compared to their accident rates before inspection)
White (1986a) NZ	**10%-15%** (in accident rate)
Crain (1981) USA	found reduction in accident rate, but no figures given
Loeb & Gilad (1984) USA	fatality and accident rates found to decrease, but no proportion figures given

Table 2.3 Effect of PMVI on vehicle defects

Study	Figures
Asander (1992) lit review	**7%-8%** of vehicles with serious defects replaced with new vehicles
NHTSA (1989) USA	**0.25%-2.5%** greater proportion of crashed vehicles with a component failure reported to have contributed to the crash in states without PMVI compared to states with PMVI **2.5%** more common to have tyre failure in non-PMVI states

Table 2.4 Percentages of crashed vehicles with defects that played a significant causal role in the accident

Study	Percentage
McLean et al (1979) Australia	**1.5%** of motorcycles **2.9%** of cars
Treat (1977) USA	**4.5%** of cars
Rompe and Seul(1985) lit review	**3%-24%** **1.3%** (Japan)
Asander (1992) lit review	**23%** (direct causes or increasing damage or injury) (Finland) **7-9%** (major causal role, a contributing cause, or by increasing the consequences of the accident) (Denmark)
Gardner (1995) lit review	**2%-10%**
RACQ (1990) lit review	**5%**

Table 2.5 Percentages of crashed vehicles with defects that played a contributory role in the accident

Study	Percentages
Grandel (1985) Germany	**6.5%** of crashed passenger cars **5%** of crashed two wheel vehicles
Treat (1977) USA	**12.6%** of cars
Rompe and Seul(1985) lit review	**4%-19%** (and possibly up to 33%)
Asander (1992) lit review	**23%** (direct causes or increasing damage or injury) (Finland) **7-9%** (major causal role, a contributing cause, or by increasing the consequences of the accident) (Denmark)
CCRAM (1978) Melbourne (from Forest and Youngman)	**5.8%** [**0.6%-1.8%** of these defects may have been detected in an inspection]
Haworth et al. (1997) - single vehicle crashes – Australia	**3%**
Haworth et al. (1997) – motorcycle crashes – Australia	**12%** overall **28%** for single vehicle crashes **7%** for multi-vehicle crashes

In summary:

- Table 2.2 shows that the effect of PMVI on accident rates ranged from no effect to decreasing the accident rate by up to 16%, and by up to 21% if inspection is regular. Rompe & Seul in citing US studies, suggest that PMVI could reduce accidents caused by vehicle defects by about 50%.

- The effect of PMVI on the incidence of defects can be seen in table 2.3. Here it can be seen that PMVI reduces the incidence of defects in the vehicle fleet by up to 2.5% (one study only). In Sweden, it was found that 7-8% of vehicles with serious defects were replaced after the introduction of PMVI.

- From table 2.4 it can be seen that a range of between 1.3% and 24% of crashed vehicles had a defect that played a significant causal role in the crash. Based on studies that carried out in-depth inspection and crash investigations (McLean, 1979: Treat, 1977), defects play a significant causal role in 2.9% to 4.5% of car crashes.

- From table 2.5 it can be seen that between 3% and 19% of crashed vehicles had a defect that played a contributory role in the crash. Perhaps the most comprehensive studies are Grandel (1985) and Treat (1977) and these indicate that vehicle defects are a contributing factor in 6.5% to 12.6% of car crashes. For motorcycle crashes, it would appear that in 5% to 12% of crashes defects play a contributory role.

3.0 ROADWORTHINESS AND FATAL SINGLE VEHICLE CRASHES

The **Case-control study of fatal single-vehicle crashes** (Haworth, Vulcan, Bowland and Pronk, 1997) included information about 127 fatal single-vehicle crashes that occurred within 200 km of Melbourne during the 12-month period from 1 December 1995 to 30 November 1996. The cases had location, driver/rider and vehicle characteristics. The controls were (non-crash) trips that also had location, driver/rider and vehicle characteristics.

Most of the crashed vehicles were cars. However, 10 crashes involved motorcycles, 7 involved light commercial vehicles and 3 involved trucks. The control vehicles were cars or light commercial vehicles. Those cases which involved cars and light commercial vehicles were compared with controls to derive relative risk estimates.
The study provides two types of information relevant to crashworthiness and crash involvement:

- estimates of risk associated with age of the vehicle
- inspection reports for vehicles involved in the crashes.

3.1 VEHICLE AGE

The year of manufacture was available for 89% of crashed cars and light commercial vehicles and for those controls where a follow-up interview was conducted. On average, crashed vehicles were two years older than control vehicles ($t(672)=-3.3$, $p<.01$).

Only one crashed vehicle and five control vehicles were manufactured before the introduction of seat belts in 1969. Most of the Australian Design Rules that pertain to vehicle safety apply to vehicles manufactured from 1978 on. The proportions of crashed and control vehicles manufactured before 1978 were examined to ascertain whether they were at greater risk of being involved in a fatal single vehicle crash than vehicles manufactured after this date.

Overall, 21% of crashed vehicles and 9% of control vehicles were manufactured before 1978, giving an unadjusted odds ratio for pre-1978 vehicles of 2.5. However, it is possible that some characteristics of the drivers of older vehicles may have contributed to the greater crash risk of the vehicles. The analyses that follow examine the contributions of age of the driver, BAC level and metropolitan or rural travel to the elevated risk for the older vehicles.

The percentages of cases and controls where the vehicle was manufactured before 1978 as a function of driver BAC level, sex and age and location and distance driven are presented in Table 1. The unadjusted and adjusted odds ratios associated with the vehicle being manufactured before 1978 are summarised in Table 2.

The small numbers of cases and controls at some BAC levels made the relationship of BAC level with driving a pre-1978 vehicle difficult to detect. Adjustment of the odds ratio by BAC level resulted in only a small change (from 2.5 to 2.7). Therefore the increased risk of crashing for pre-1978 vehicles does not result from drivers of older vehicles being more likely to have positive BACs.

Table 3.1 Percentages of cases and controls driving a pre-1978 vehicle. Percentages are of known

	Percent of cases	Percent of controls
Overall	21	9
BAC level		
zero	23	10
<=.050*	0	6
.051 to .149*	0	0
>=.150	29	-
Driver sex		
male	22	12
female	17	4
Driver age		
under 25	14	15
25 to 59	22	9
60 and over	33	8
Location		
metropolitan area	18	10
rest of study area	26	9
Distance per week (km)		
up to 50 km	42	50
51-100	0	0
101-200	0	4
201-300	42	6
301-400	40	13
over 400	16	9

* percentages based on small numbers and so may be unreliable

Table 3.2 Unadjusted and adjusted odds ratios and confidence intervals for pre-1978 vehicle (cf later model vehicles). Highlighted odds ratios are statistically significant at the 95% level

	Odds ratio	Confidence interval
Unadjusted	**2.5**	1.4 - 4.3
Adjusted for...		
BAC level	**2.7**	1.4 - 5.3
Sex	**2.4**	1.4 - 4.1
Age of driver	**2.4**	1.3 - 4.2
Metropolitan/rural	**2.5**	1.4 - 4.4
Distance per week	**2.3**	1.2 - 4.5
BAC level and sex	**2.7**	1.4 - 5.2
BAC level and age of driver	**2.4**	1.2 - 4.9

Males were more likely than females to drive cars manufactured before 1978 for both cases and controls, therefore adjustment for driver sex did not change the odds ratio for driving a pre-1978 vehicle.

Crashed vehicles in the rest of the study area were more likely to have been manufactured before 1978 than those in the Melbourne metropolitan area. However, this finding was not evident for control vehicles. Adjustment for metropolitan/rural did not markedly change the odds ratio for driving a pre-1978 vehicle, however.

For cases, the proportion of vehicles which were manufactured before 1978 appeared to increase with the age group of the driver (see Table 1). This was not found for controls, however. The odds ratio for driving a pre-1978 vehicle was not affected by adjustment for driver age group.

Table 1 shows that control drivers who drove up to 50 km per week were more likely to be driving pre-1978 vehicles than controls who drove further. An analysis of variance showed that the oldest vehicles tended to travel less distance per week than newer vehicles ($F(5,616)=3.0$, $p<.05$). The design of the study tended to recruit fewer of those controls who drive less, and therefore inflated the odds ratio for factors related to driving less. Adjustment of the odds ratio by distance travelled per week reduced it slightly, but it remained statistically significant. Therefore the reduced distance travelled did not account for all of the elevated risk of the older vehicles.

In conclusion, the odds ratio of 2.5 for driving a pre-1978 vehicle did not drop when adjusted for a number of driver factors which were considered possible confounders. Therefore the increase in risk in driving cars of this age appears to be a real effect, not something reflecting the drivers or the areas in which these vehicles are driven.

3.1.1 Vehicle age - Summary and interpretation

Vehicles manufactured before 1978 comprised 21% of crashed vehicles and 9% of control vehicles. Thus the odds of being involved in a fatal single vehicle crash were 2.5 times greater for a driver of a pre-1978 vehicle than a newer vehicle. Adjustment for a number of driver-related variables (BAC level, sex, age) and characteristics of the driving pattern (metropolitan/rural, distance per week) had little effect on the odds ratio. This suggests that the effect of the age of the vehicle reflects some characteristics of the vehicle, rather than characteristics related to its driver or pattern of use.

It is unclear from this study whether the characteristics of the vehicle responsible for the increase in risk with vehicle age relate to active safety (braking, steering etc.) or to passive safety (structural integrity, and occupant protection features). Both active safety and, to a larger extent, passive safety could be poorer on older cars because of poorer initial design or because of deterioration over time (reductions in roadworthiness). Thus while this study shows that vehicle characteristics contribute to a greater risk of fatal crash involvement for older vehicles, it is unclear by what mechanism this occurs.

3.2 INSPECTIONS OF CRASHED VEHICLES

Overall, 102 of the 127 crashed vehicles in the study were inspected by the Victoria Police Accident Investigation Section. Of these vehicles, 38 (37%) were found to be unroadworthy.

The results for cars and light commercial vehicles are summarised in Table 3. While 34/93 vehicles were judged to be unroadworthy, in 29 of the 34 unroadworthy vehicles, the mechanical faults were not considered to have caused or contributed to the collision – leaving 3 cases in which defects were considered to have contributed, and 2 unknown. The unroadworthy vehicles were, on average, ten years older than the roadworthy vehicles. The vehicles with defects that caused or contributed to the collision were not older than the other unroadworthy vehicles.

Table 3.3 Mechanical inspection results for cars and light commercial vehicles involved in fatal single vehicle crashes. Vehicle age not known for one car

Category of vehicles	Number of vehicles	Mean vehicle year
Roadworthy	59	1986.63
Unroadworthy		
- all	34	1976.76
- contributed	3	1990.33
- did not contribute	29	1979.07
- contribution unknown	2	1974.00
All inspected	93	1983.02
Not inspected	20	1983.45

The most commonly identified types of mechanical defects were:

- having less than the required tread depth on one or more tyres (20)
- rust (11)
- brakes (not handbrake) (9)
- suspension problems (6)
- muffler (4)
- mismatched tyres on the same axle (3)
- steering problems (3)

The mechanical defects which were identified as contributing to the collisions were brake fade resulting from failure to replace brake fluid, tread separation and lack of tread depth.

There were 10 motorcycles involved in fatal single vehicle crashes, of which 7 were inspected. Two were found to be unroadworthy on account of insufficient tyre tread depth but this was not considered to have contributed to the crashes. These motorcycles were 1985 and 1986 models (close to the mean age of the 10 motorcycles).

3.2.1 Crashed vehicles inspection - Summary and interpretation

The vehicle inspections conducted as part of the **Case-control study of single vehicle crashes** found that about 37% of crashed vehicles were unroadworthy but that mechanical defects had contributed to only about 3% of crashes. The defects which were judged to have contributed to the crashes related to tyres and brakes. Defects of these systems were common in the vehicles that were judged unroadworthy, but that the defects had not contributed to the crash. In general, the defects identified as contributing to the crashes related to active, not passive safety. One might have expected that rust may have reduced the passive safety of vehicles and thus contributed to the severity of the crash, but such a contribution was not identified by the inspectors. Perhaps it is easier to identify defects that relate to active safety than those that relate to passive safety.

4.0 ROADWORTHINESS IN THE MOTORCYCLE CASE-CONTROL STUDY

This section presents some findings of the *Case-control study of motorcycle crashes* (Haworth, Smith, Brumen and Pronk, 1997) relevant to motorcycle roadworthiness. The cases in the study were 222 motorcycle crashes occurring on public roads in the Melbourne metropolitan area from late November 1995 to 30 January 1997 in which the rider or pillion was taken to one of the participating hospitals or died. The controls were 1195 motorcyclist trips that passed the crash site at the same time of day and day of week as the crash occurred.

In the study, 167 of the crashed motorcycles were inspected. Time constraints prevented inspection of the control motorcycles. Three types of information collected in this study are relevant to motorcycle roadworthiness:

- estimation of the effect on crash involvement of age of the motorcycle
- inspections of crashed motorcycles
- judgements of the contribution of mechanical defects to crashes

4.1 AGE OF THE MOTORCYCLE AND RISK OF CRASH INVOLVEMENT

The year of manufacture was available for 97% of crashed motorcycles and those controls for which a follow-up interview was conducted. The median years of manufacture of case and control motorcycles are summarised in Table 1. Since most of the data collection for this study occurred in 1996, the table shows that half of the motorcycles were less than six years old. As a general comment, this suggests that the motorcycle fleet is considerably younger than the car fleet.

Table 4.1 Median year of manufacture of case and control motorcycles

	Cases	Controls
Overall	1991	1990
BAC=.000	1992	1990
BAC>.000 *	1988	1990
Rider sex		
male	1991	1990
female *	1995	1990
Rider age		
under 25	1991	1991
25 to 34	1991	1990
35 and over	1992	1986
Licence		
learner	1990	1991
probationary	1992	1991
full	1992	1989
Work-related trip	1990	1990
Nonwork-related trip	1991	1990

* percentages based on small numbers and so may be unreliable

The median year of manufacture for crashed motorcycles was 1991 while the median year of manufacture for control motorcycles was 1990. Case motorcycles were statistically significantly younger than control motorcycles (Mann-Whitney U=33422, $p<.05$).

This may partly reflect that older control riders generally rode older motorcycles, while the same was not found for older crashed riders.

The results of this study show that motorcycles are younger than cars, on average. There is no indication that older motorcycles are more likely to be involved in crashes, possibly because older motorcycles are often ridden by older, more experienced riders.

4.2 INSPECTIONS OF CRASHED MOTORCYCLES

As noted earlier, 167 of the 222 motorcycles in crashes were able to be inspected. The inspectors found that it was possible to judge the mechanical condition prior to the crash of all but six (4%) of the motorcycles (see Table 2). They judged that 39% of the motorcycles inspected were in poor or fair condition prior to the crash, 37% were in good condition and 21% were judged to be in excellent condition prior to the crash. Several of the motorcycles which were judged to have been in excellent condition prior to the crash were almost new. Forty-four (26%) of the motorcycles inspected showed signs of rust.

State of cleanliness and mechanical condition appeared to be related. Almost all of the clean motorcycles were judged to be in good or excellent mechanical condition. The dirty motorcycles ranged from poor to good mechanical condition. Most of the motorcycles in poor mechanical condition were dirty. Often leakage of oil and other fluids had contributed to the build-up of grime on these motorcycles.

Table 4.2 Mechanical condition of the crashed motorcycles inspected

Mechanical condition before crash	Number of motorcycles	Percent of motorcycles
Poor	17	10
Fair	48	29
Good	61	37
Excellent	35	21
Unknown	6	4
Total	167	100

Approximately 60% of the motorcycles inspected had dents or scratches on their petrol tanks. Just over a third of the motorcycles inspected were found to have the correct tyre pressure. Approximately a quarter of the motorcycles inspected had under-inflated front or rear tyres (see Table 3).

Table 4.3 Percentages of crashed motorcycles inspected according to tyre pressures

Tyre pressure	Front (n=167)	Rear (n=167)
Deflated due to crash	7	4
Under-inflated	27	25
Correct pressure	34	39
Overinflated	3	3
Unknown	29	29
Total	**100**	**100**

The head and tail lights, indicators and brake lights were examined. Table 4 shows that all lights were still functioning after the crash for approximately 50% of the motorcycles inspected. Further it was established that the lights were functioning prior to the crash for a further 9% of the motorcycles inspected. All lights were broken in only 3% of the motorcycles.

The steering was not damaged for approximately two-thirds of the motorcycles inspected (see Table 5). In two of the crashes there was evidence that there may have been steering problems prior to or contributing to the crash, however in one case this could not be ascertained due to the extent of crash damage. In total, 14 motorcycles were found to have defective steering, however it was not known whether this was due to crash damage or to a pre-existing problem. Ten of the motorcycles were so damaged that assessment of the steering was not possible.

Table 4.4 Condition of the lights of the crashed motorcycles inspected

Condition of the lights	Number of motorcycles	Percent of motorcycles
All lights functioning	86	51
All lights functioning prior to crash	15	9
All broken	5	3
Indicator(s) only broken	14	8
Some damage to lights	26	16
Not fitted	13	8
Unknown	8	5
Total	**167**	**100**

Table 4.5 Condition of the steering of the crashed motorcycles inspected

Condition of the steering	Number of motorcycles	Percent of motorcycles
Good	113	68
Damaged - good before crash	29	17
Damaged - possible problem before crash	2	1
Damaged - unclear before crash	1	1
Damaged beyond assessment	1	1
Defective	14	8
Unknown	7	4
Total	**167**	**100**

The condition of the drivetrain was good for approximately 60% of the motorcycles inspected (see Table 6). In almost a quarter of the cases, however, there was evidence of a worn or loose chain.

Table 4.6 Condition of the drivetrain of the crashed motorcycles inspected

Condition of the drivetrain	Number of motorcycles	Percent of motorcycles
Good	103	62
Worn or loose chain	41	25
Damaged in crash	1	1
Not applicable - shaft drive	19	11
Unknown	3	2
Total	**167**	**100**

Approximately 15% of the motorcycles inspected had brakes in poor condition (front 16% and rear, 18%) (see Table 7). The most common problem with the brakes was insufficient pad thickness (2 mm or less).

Table 4.7 Percentages of crashed motorcycles inspected according to the condition of the brakes

Condition of the brakes	Front (n=167)	Rear (n=167)
Good	82	78
Insufficient pad thickness	11	15
Poorly adjusted, too much travel	1	1
Damaged in crash	4	2
Unknown	2	4
Total	**100**	**100**

About two thirds of the motorcycles inspected were observed to be free of oil leakage. Oil leaks were identified for 51 motorcycles (31%), but it was unclear the extent to which the leaks preceded the crash.

Problems with tyre tread were more common for rear tyres (19%) than front tyres (7%) (see Table 4.8).

Table 4.8 Percentages of crashed motorcycles inspected according to the condition of the tyres

Condition of the tyres	Front (n=167)	Rear (n=167)
Little sign of wear	46	44
Tread somewhat worn	44	35
Tread badly worn	7	14
Bald	1	5
Unknown	3	1
Total	**100**	**100**

In summary, 39% of the motorcycles were judged to be in poor or fair mechanical condition prior to the crash. The most common mechanical defects identified in the crashed motorcycles were:

- under-inflated front or rear tyres
- rust
- worn or loose chain
- insufficient brake pad thickness (front or rear)
- tread badly worn (particularly rear)

For a number of components (e.g. steering, lights, oil leakage), crash damage made it difficult to assess pre-crash condition.

4.3 CONTRIBUTION OF MECHANICAL DEFECTS TO CRASHES

The Motorcycle Consultant reviewed the cases and identified several common contributory factors to crashes: failure to respond, ineffective braking, inappropriate positioning and mechanical faults. For 94 crashes (42%) there was insufficient information available to judge whether any of these factor had contributed to the crash.

The contributory factors are summarised in Table 9. Mechanical faults contributed to about 12% of crashes overall, but the contribution was much greater in single vehicle crashes (28%) than in multi-vehicle crashes (7%).

Table 4.9 Rider contribution to single and multi-vehicle crashes. Percentages are of known

Rider contribution to the crash	Single vehicle crashes (n=29)	Multi-vehicle crashes (n=99)	All crashes (n=128)
Failed to respond	3	21	17
Ineffective braking	41	13	20
Inappropriate positioning	3	25	20
Mechanical fault	28	7	12
No rider contribution	24	33	31

There appears to be an association between drink riding and poor mechanical condition of the motorcycle. In crashes where the rider had BAC>.000, mechanical fault was judged to contribute to 18% (2/11) of crashes. In contrast, mechanical fault was judged to contribute to only 7% (5/72) of crashes where the rider had BAC=.000 (see Table 10).
A similar pattern was found when the judgements of mechanical condition made during the motorcycle inspections were examined. Where BAC=.000, 11% (10/94) of motorcycles were judged to be in poor or fair mechanical condition but this was found for 29% (6/21) of motorcycles inspected where BAC>.000. Where BAC was unknown, 13% (7/52) of motorcycles inspected were judged to be in poor or fair mechanical condition.

Table 4.10 Rider contribution to crashes with and without alcohol. Percentages are of known

Rider contribution to the crash	BAC=.000 (n=72)	BAC>.000 (n=11)	All crashes with BAC known (n=83)
Failed to respond	14	9	13
Ineffective braking	21	9	19
Inappropriate positioning	25	46	28
Mechanical fault	7	18	8
No rider contribution	33	18	31

In summary, mechanical defects were judged to have contributed to 12% of crashes. The contribution was greater to single vehicle crashes and to crashes in which the rider had consumed alcohol. Riders in single vehicle crashes were twice as likely to have consumed alcohol than riders in multiple vehicle crashes. The relationship between contribution of defects to crashes and alcohol consumption may relate to riders who are willing to drink and ride being less careful about other activities, including maintenance of their motorcycle.

4.4 MOTORCYCLE CASE-CONTROL STUDY - SUMMARY

The *Case-control study of motorcycle crashes* has shown that:

- defects are relatively common in crashed motorcycles
- defects contribute to about 12% of motorcycle crashes
- despite motorcycles being relatively newer, on average, than cars
- there are no clear difference in crash risk for motorcycles of different ages – any pattern appears to be obscured by older, more experienced, riders having older motorcycles.

5.0 ANALYSIS OF CORONER'S DATABASE (VICTORIA)

Two sets of analysis were carried out with the results presented in the following two sections.

5.1 THE VICTORIAN CORONER'S FACILITATION SYSTEM (CFS)

This data base is currently held by Monash University Accident Research Centre (MUARC), and spans the period **July 1989 to June 1995**, and contains 9,238 records for the six-year period. Vehicles were defined as passenger cars, motorcycles, vans, utilities and minibuses (seats 8-20) and represented 3538 cases in the entire database. They were selected by using factor codes representing each vehicle type.

Defective or unroadworthy vehicles contributing to crashes were identified by reading the text descriptions for each of the 3538 cases.

Factor codes representing various vehicle parts such as brakes, doors and other parts were also used. A thorough search of the database for vehicle crashes caused by defective or unroadworthy vehicles yielded 42 cases.

Thirty-one cases had unroadworthy passenger cars while 8 had unroadworthy motorcycles with the remaining 3 cases involving vans.

Defective tyres were the cause of the injury event for 15 cases of which 9 were described as being unroadworthy or bald, 5 were flat or deflated rapidly while in motion and 1 wheel came off.

Other problems included faulty brakes (4), electrical fires (4), seatbelts (2), fractured ball joint (1), faulty lights (1), jammed throttle cable (1) and a faulty bonnet (1).

The remaining 13 cases did not provide any further details regarding the nature of the vehicles' unroadworthiness.

It is noted that in most cases the condition of the vehicle as regards roadworthiness and possible contribution of defects to the crash or injury outcome, is often based on the assessment by the Police Accident Investigation Section.

The following Table sets out a summary of the text description obtained for the 42 cases identified from the Coroners database for the period 1989-1995. It is possible to obtain far more detail information for each case from examination of each case file stored[2] by the Coroner's Office.

The results presented here are a subset of the larger analyses presented in Section 5.2.

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[2] Case files are able to be inspected at the State Coroner's Office provided the case is complete (Inquest held). Files more than 3 years old are archived at Laverton, and are accessible only with due notice.

30 March, 1999

Victorian Coroner's Facilitation System (CFS) July 1989 to June1995

Resutls of search for vehicle defects as a factor in crash causation

Summarize - Selecting unroadworthy vehicles (passenger cars, motorcycles, vans, utilities and minibuses)

Case Summaries

				CASENUM	Age (yrs)	SEX	TEXT1	TEXT2	TEXT3
DEATHYR	1989	1		2935	8	M	Deceased was attempting to cross the road and was struck by	a motor vehicle. The motor vehicle was unroadworthy.	
		2		3808	22	F	Deceased driving vehicle,had flat tyre veering on wrong side	of road, colliding with another vehicle travelling opposite	direction.Car unroadworthy. Killed 2 others in other car
		3		3809	82	F	Deceased driving vehicle, collided with another travelling	opposite direction which had a flat tyre (both front tyres	bald) and veered to wrong side of road. Three killed
		4		3810	84	F	Deceased passenger vehicle,collided with another travelling	opposite direction with a flat tyre (Both front tyres bald)	and which veered to wrong side of road. 3 killed.
		5		2853	32	M	Deceased (driver) involved in head-on collision when another	vehicle lost control around bend crossing centre line of	road. Other driver (BAC 0.078%) had unroadworthy tyres.
		6		3854	15	F	The car in which the deceased was passenger, left the	roadway and struck a tree. The car was not registered and	had problems.
		7		3969	19	M	Deceased under influence of alcohol, crossed the road and	was hit by a car that was of unroadworthy condition.	
		8		3122	31	M	The deceased was driving his motor vehicle when part of a me	tal brake from a trailer parted & was projected through the	windscreen killing him. Brake was unroadworthy
		Total	N	8	8	8	8	8	8
	1990	1		620	55	F	Deceased drove her car out of her garage, then alighted to	close the garage door when the car rolled on top of her.	The car had a faulty service brake.
		2		1396	6	M	Died from injuries received whilst as an off side rear	passenger - vehicle driven by his father had a blow out and	collided with a tree.
		3		1752	19	M	Deceased was unlicensed driver, riding unregistered and	unroadworthy m/cycle. Lost control of m/cycle, hitting a	gutter then a power pole. Not wearing a crash helmet.
		4		2374	22	M	Deceased was riding his motorcycle at an excessive speed and	collided with the passenger side of motor vehicle making a	right hand turn. (bald rear tyre on motorcycle,wet road)
		5		2080	26	M	Deceased riding his motor bike when motor vehicle making a	right hand turn from side street came into the path of the	deceased. Tread on motor bike tyres were inadequate.
		6		1834	52	M	Deceased was riding his motor bike when the rear wheel	deflated and was thrown from the bike. The tyres were not	designed for bitumen roads.
		7		3128	18	M	Deceased was on his motorcycle travelling over 100kph, when	his lights failed (dark at time) just before a bend. He hit	the kerb, became airbone, hit road sign & skidded 10m.
		8		2592	21	M	Deceased lost control of his motor vehicle and collided with	a tree. Deceased was speeding, roads wet and dark, tyres on	vehicle unroadworthy and deceased had drunk alcohol.

Page 1

Case Summaries

				CASENUM	Age (yrs)	SEX	TEXT1	TEXT2	TEXT3
DEATHYR	1990	9		3542	22	M	Deceased died from injuries received as a front seat	passenger in a car which went out of control due to the	bonnet flying up, and hit an SEC pole.
		10		2639	2	F	The deceased suffered severe burns in a car fire which	was caused when her mother turned the ignition on. The	deceased died months later in hospital.
		Total	N	10	10	10	10	10	10
	1991	1		673	19	M	Deceased drove his vehicle at a fast speed with a BAC .188%.	Failed to negotiate a curve and struck a tree. Vehicle was	also unroadworthy prior to accident.
		2		2242	1	F	Deceased was a rear seat passenger (restrained in a baby	seat) in a car which lost control and rolled down an	embankment. A front tyre was unroadworthy.
		3		4234	54	M	Deceased left car motor running with handbrake on while he	went to shut gate. On steep incline, handbrake did not hold	and car drove into the deceased, knocking him to ground.
		4		4123	19	F	Deceased was a back seat passenger in an unregistered	unroadworthy car which while excecuting a right hand turn	moved into path of another car. Driver had a BAC 0.109%.
		5		4135	31	F	Deceased (with BAC 0.12%) was driving at a fast rate, lost	control, and overturned down an embankment. Car was	unroadworthy, tyres were mismatched and lacked tread.
		6		4124	25	M	Deceased was a front seat passenger in an unregistered and	unroadworthy car making a right hand turn and moved into the	path of another unroadworthy car (driver BAC .109%).
		Total	N	6	6	6	6	6	6
	1992	1		939	37	M	Deceased lost control of his motor vehicle and collided	with a tree. Deceased probably fell asleep and the car was	unroadworthy.
		2		795	18	M	Deceased was riding his motor-bike, failed to give way	at an intersection and collided with an 8 ton truck.	The motor-bike was unroadworthy.
		3		529	27	M	Deceased was a passenger in a 1934 Chevrolet (no seat belts)	when the wheels moved onto gravel, and the car rolled	several times.
		4		3458	37	F	Deceased was a passenger in a car travelling at an	excessive speed. The tyre separated from the wheel, car	lost control and hit a pole. Driver had a BAC 0.092%
		5		3816	3	M	Deceased was one of three children in a parked van, he died	as a result of a fire. The fire was started as a result of	leads to a warning light shorting out.
		6		3817	3	M	Deceased was one of three children in a parked van, he died	as a result of a fire. The fire was started as a result	of leads to a warning lamp shorting out.
		7		3818	5	F	Deceased was one of three children in a parked van, she died	as a result of a fire. The fire started as a result of	leads to a warning lamp shorting out.
		8		3938	18	M	Deceased was driving an unroadworthy car with faulty brakes,	lost control and collided head on with a truck. Deceased	died 4 weeks later in hospital.
		9		3998	41	F	Deceased whilst driving, braked heavily to make a right hand	turn, was hit in the back, then pushed across the carriage-	way & collided head on with another car. Seatbelt broke.
		Total	N	9	9	9	9	9	9
	1993	1		1673	62	M	Deceased was a front seat passenger in a car which collided	with a tree. A fracture in the ball joint would have caused	the collision.
		2		93	36	M	Deceased was travelling on a gravel road and collided with a	tree, deceased's body was incinerated. The car was	unregistered and unroadworthy.
		3		231	21	M	Deceased whilst driving left the road and collided with 2	large trees. The accident was due to the rapid deflation of	a front tyre - repair patch in the tyre was sub-standard

Case Summaries

				CASENUM	Age (yrs)	SEX	TEXT1	TEXT2	TEXT3
DEATHYR	1993	4		2343	20	M	Deceased left a party drunk (BAC 0.20%) and appeared tired.	Upon driving, he mounted the kerb and collided with an SEC	pole. The car was unroadworthy.
		5		3098	6	M	Deceased was a passenger in an unroadworthy vehicle that	lost control negotiating a bend, veered onto the grass, hit	an embankment and rolled over.
		Total	N	5	5	5	5	5	5
	1994	1		964	19	M	Deceased, while riding his motorcycle, lost control and hit	an SEC pole. The motorcycle was unroadworthy and the	deceased did not hold a licence. Cannabinoids detected.
		2		955	24	M	Deceased, with a BAC 0.22%, lost control of his car and hit	a tree. The car had bald and mismatched tyres.	
		3		1656	16	M	Deceased was riding an unroadworthy unregistered trail bike	at Monash Reserve. The throttle cable jammed and deceased	lost control, crashing into the corner of a house.
		4		1882	61	M	Deceased lost control of his car and moved to the wrong side	of the road and collided with an oncoming car. Two tyres	were worn and the road was wet at the time.
		Total	N	4	4	4	4	4	4
	Total	N		42	42	42	42	42	42

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5.2 VICTORIAN STATE CORONER'S DATA BASE (1989-1998)

This second analysis was carried out directly by the Research and Information Group, Victorian Institute of Forensic Medicine. The search was for passenger vehicle and motorcycle crashes in which vehicle defects (or unroadworthy vehicles) were identified as a contributing factor in crash causation or injury outcome. The results of this search overlap the result of the MUARC search of the Coroner's data base for the period 1989 to 1995.

The cases identified are presented in **Appendix 2.** It is noted that in some of these cases, vehicle defects or lack of roadworthiness are noted as ***not*** being a contributing factor.

For the ten-year period a total of 4400 crash cases (fatalities) were searched, of which 234 cases noted 'defects' or 'roadworthiness'. Of the 234 cases over the 10 year period, a subset of 64 cases were identified for the 3 year period from 1996 to 1998. 10 of these files were not held at the coroner's office. Thus, 54 cases were investigated in detail. Information was obtained by reading the files themselves at the coroner's office. The remaining files for the period prior to 1996 are archived and not readily accessible.

Of the 54 crashes, 3 were found to have defects that caused the crash, 15 had defects that contributed to the crash, and 36 had defects that did not contribute to the crash at all.

The defects that caused the crashes were as follows:

- the near side rear axle broke and the wheel assembly detached
- the steering wheel was not secured properly
- the drag link failed and caused a total and sudden loss of steering control

Of the crashes in which the defect contributed to causing the crash, 11 were due to worn tyres, 3 were due to faulty brakes and one crash was due to both worn tyres and faulty breaks.

Examples of crashes in which the defect did not play a role at all include a drunk pedestrian being run over in the dark (not seen by the driver), a drunk and speeding driver loosing control on a bend and hitting a tree, and a driver falling asleep and veering off the road and hitting a tree.

Incidence of defects in crashes

The incidence of defects contributing or causing crashes can be determined by comparing the number of cases with defects identified as causal (3 cases) or contributing (15 cases) factors with the pool of cases inspected.

A search of the Coroner's database identified that of the 1,185 fatal cases over the three year period from 1996 to 1998, 224 had inspections carried out by the AIS.

Thus, in 1.3% (3/224) of fatal crashes, a defect was identified as the causal factor in the crash and in 6.7% (15/224) of fatal crashes, a defect was identified as having contributed to the crash.

Overall, based on this Coronial data it would appear that defects play a role in around 8% of crashes.

It should be noted that the Coronial database does not record the existence of a Police Mechanical Inspection Section (MIS) report. It does record AIS investigations. Based on discussions with Mr Simon Jolly (Research and Information Coordination Group,Victorian Institute of Forensic Medicine) it would appear that in the Coronial database MIS reports are only received as part of an AIS investigation. Thus the exact number of cases inspected is not completely certain.

6.0 SUMMARY

6.1 STUDY SCOPE AND OBJECTIVES

The Road Safety Committee of the Victorian Parliament is conducting an Inquiry into Vehicle Roadworthiness, and the effectiveness of vehicle roadworthiness systems in reducing the incidence and severity of crashes.

This study is in response to a request by Victorian Automobile Chamber of Commerce (VACC) to assist in their submission, in responding to Question 1 of the Parliamentary Committee's Terms of Reference:

> *2. The extent to which vehicle roadworthiness is involved as a primary or contributing factor in crash causation.*

The study focuses on roadworthiness for passenger vehicles and motorcycles.

6.2 DEFINITION OF ROADWORTHY

It is important to define what is meant by a vehicle being 'roadworthy' as this can vary between jurisdictions and in different studies. A roadworthy vehicle is one in which there exist no safety-related defects at a particular time. It can also be regarded as that measured by the acquisition of a roadworthiness certificate - an indication that the vehicle is considered safe to drive at the time that it was inspected.
The detection of defects, and judgement about what classifies as a defect, are, to some extent, relative concepts, rather than absolute ones, and one that can vary with vehicle model, age and time as components deteriorate or fail (for example, a signal lamp that ceased to function).

6.3 METHOD

The work presented in this report comprises four main stages or activities.

- Literature review of Australian and international studies and findings on the effect of: vehicle defects, vehicle inspection systems, ageing of cars.
- Analysis of the Victorian *Case-Control Study of Fatal Single-Vehicle Crashes* in regard to vehicle roadworthiness issues. The study included information about 127 fatal single-vehicle crashes that occurred within 200 km of Melbourne during the 12-month period from 1 December 1995 to 30 November 1996.
- Analysis of the Victorian *Case-control study of motorcycle crashes* in regard to motorcycle roadworthiness. The cases in the study were 222 fatal and serious injury motorcycle crashes from late November 1995 to 30 January 1997.
- Analysis of Coroner's Database (Victoria), For the period 1989-1998, defective or unroadworthy vehicles and motorcycles contributing to crashes were identified by searching the text descriptions.

6.4 FINDINGS

The following section summarises the key findings from the study regarding the role of PMVI in relation to crashes and defect incidence; the contribution of defects to crashes; and the effect of vehicle age on crashes.

6.4.1 The Effects of Periodic Motor Vehicle Inspection Programs (PMVI)

- The effect of PMVI on accident rates ranged from no effect to decreasing the accident rate by up to 16%, and by up to 21% if inspection is regular. Rompe and Seul (1995) in reviewing US studies suggest that periodic roadworthiness tests could reduce the number of accidents caused by vehicle defects by about 50%.
- PMVI reduces the incidence of defects in the vehicle fleet by up to 2.5% (one study only). In Sweden, it was found that 7-8% of vehicles with serious defects were replaced after the introduction of PMVI.
- Vehicle inspection programs may influence and reduce accident rates by increasing the understanding of the driver for the need for regular maintenance, safety issues and the condition of their own car (Rompe and Seul (1985)).

6.4.2 The contribution of defects to crashes

- Between 1.3% and 24% of crashed vehicles had a defect that played a significant causal role in the crash. Based on studies that carried out in-depth inspection and crash investigations (McLean, 1979: Treat, 1977), defects play a significant causal role in 2.9% to 4.5% of car crashes.
- Between 3% and 19% of crashed vehicles had a defect that played a contributory role in the crash. Perhaps the most comprehensive studies are Grandel (1985) and Treat (1977) and these indicate that vehicle defects are a contributing factor in 6.5% to 12.6% of car crashes. For motorcycle crashes, it would appear that in 5% to 12% of crashes defects play a contributory role.
- Analysis of crashes and findings in the Coronial files and database (refer Section 5.2 and Appendix 2) indicate that defects play a role in an estimated 8% of crashes in Victoria.
- Overall it would appear that vehicle defects are a contributing factor in over 6% of crashes.

6.4.3 Effect of Vehicle age on crashes

Various studies have identified that older vehicles are over-represented in serious injury crashes. In Australia, Haworth et al (1997) determined the odds of being involved in a fatal single vehicle crash were 2.5 times greater for a driver of a pre-1978 vehicle than a newer vehicle. It is unclear from this study (and in other studies which have examined vehicle age) to what extent this is due to some effect of vehicle age (including defects, deterioration of safety related components), or to improvements in crashworthiness of modern vehicles compared with older vehicles.

6.4.4 Methodological problems with the studies

One reason why there may be variation in the results may be that methodological and statistical shortcomings are evident in many of the studies. Other issues relate to under-reporting of defects and the difficulty of determining defects in crashed vehicles. The expertise and level of investigation are also factors affecting determination of defects and their contribution in crashes.

Measurements of the effects of inspection programs are problematic due to the difficulty of isolating the PMVI effects from those resulting from other major safety related programs, or other differences between jurisdictions.

It is noted the most direct method that to identify the contribution of defects to crashes is to compare the proportion of defects in the vehicle fleet (specific to vehicle model) with that found in the crashed vehicle population. This would directly identify over-representation or otherwise of particular defects in relation to crashes. None of the previous studies appear to have carried out such an approach.

6.5 VEHICLE ROADWORTHINESS

Some vehicle defects clearly contribute to the occurrence of crashes. However, challenges exist in identifying systems that can adequately identify and reduce the occurrence of such defects. Even when annual inspection programs exist, a significant percentage of vehicles still have defects, rendering the vehicles 'unroadworthy'. Yet only some of these defects appear to contribute to crashes. This would suggest that only in certain circumstance are defects contributing factors in crashes. This conclusion is not at all surprising as crashes can result from a large number of factors and a chain of events, with vehicle defects being just one of these factors.

As most vehicle owners or users do maintain their vehicles, the key question is what additional measures (through compulsory PMVIs, random inspections, or other measures) are required to minimise those safety related defects that have been found to be contributing factors in crashes. It would appear that such measures must recognize that defects arise due to various factors including: lack of awareness by the owner, normal deterioration with use or age, poor quality service or repairs, defects in parts (eg. retread tyres etc) and deliberate neglect.

It is self evident from a safety viewpoint that vehicles need to be roadworthy, and that this should therefore be a condition of registration. To argue otherwise is to suggest that vehicle maintenance and condition are not important or significant aspects of safety –which is untenable, based on experience and use of any type of mechanised equipment. It is therefore essential to concentrate efforts on implementing effective measures to improve the roadworthiness of the vehicle fleet.

7.0 SUGGESTED FURTHER RESEARCH

7.1 STUDY OF EFFECTIVENESS OF COMPULSORY ANNUAL INSPECTIONS IN REDUCING VEHICLE DEFECTS

Most, if not all, of the previous studies reported in the literature review have shortcomings when it comes to assessing what the effects compulsory annual inspections would have on defects in cars in Victoria. Some of the studies are dated (and vehicles have changed as evidenced by the lengthening of manufacturers' warranty periods) whereas others were conducted in jurisdictions which may not be easily compared to Victoria.

It is tempting to consider a comparison between Victoria and New South Wales, where compulsory annual inspections have been undertaken for many years. Yet overall comparisons of crash rates between the jurisdictions are unlikely to be sensitive to the effects of inspections on defects, given that there are many other, larger factors which effect crash rate (e.g. drink driving, road quality etc).

It is proposed to examine the prevalence of defects in cars in use, in order to overcome the difficulties in using crash rates to measure the effects of compulsory annual inspections on defects in cars.

One possible methodology would be to have the same inspections carried out on a large, representative sample of cars in New South Wales and Victoria (say 1,000 vehicles in each state). Matching or statistical adjustment for the age of the car could be undertaken, if necessary. Any difference remaining would reflect the effect of compulsory annual inspections. Further analysis of the NSW sample could provide some information on the prevalence of defects as a function of time elapsed since inspection.

To identify the contribution of defects to crashes the most direct method is to compare the proportion of defects in the vehicle fleet (specific to vehicle model) with that found in the crashed vehicle population. This would directly identify over-representation or otherwise of particular defects in relation to crashes.

7.2 CHANGES IN RELATIVE IMPORTANCE OF CRASH FACTORS

As vehicle safety countermeasures are progressively implemented (eg. improved frontal crash protection; BAC enforcement programs, road blackspot programs), the distribution of contributing factors to crashes and injury will change over time. This means that new countermeasure priorities will arise as countermeasures for earlier priorities take effect.

For example Henderson (1993, p.4) notes in regard to causal factors and BAC that:

> "*Few important causal factors are documented in official statistics. This is because each crash involves a countless number of factors, each in itself with a small influence but which in combination set the scene for a crash and the resulting injury. However, alcohol use is extremely pervasive, and has a well-established relationship to crash risk. Laws helping to control alcohol use by drivers are now deeply embedded in the legal system. Thus, because fairly reliable figures are systematically collected, we are able to track alcohol involvement over the years*."

The percentage of drivers and motorcycle riders killed in Australia with a blood alcohol concentration over the legal limit has fallen from 44% in 1981 to 29% in 1996 (Federal Office of Road Safety, 1997). The percentage in 1998 in Victoria was lower than the national average, falling from 38% in 1981 to 24% in 1996.

In the context of the contribution of vehicle defects to crashes, although the percentage may appear to be small in absolute terms, its importance relative to other contributing factors may be regarded as significant. It would thus be useful to have a study which provides a perspective of the changing landscape of contributing factors to crash and serious injury risk.

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APPENDIX 1

TERMS OF REFERENCE - INQUIRY INTO VEHICLE ROADWORTHINESS

ROAD SAFETY COMMITTEE

LEVEL 8
35 SPRING STREET
MELBOURNE
VICTORIA 3000
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TERMS OF REFERENCE

INQUIRY INTO VEHICLE ROADWORTHINESS

To inquire into, consider and make recommendations on the effectiveness of vehicle roadworthiness systems in reducing the incidence and severity of crashes reporting on:

1. The extent to which vehicle roadworthiness is involved as a primary or contributing factor in crash causation.

2. The effectiveness of the existing Victorian roadworthiness system and options to improve vehicle roadworthiness which can be justified having regard to their costs and benefits.

3. The potential for vehicle roadworthiness systems that could operate as an alternative to compulsory periodic testing including an analysis of the associated benefits and costs.

4. The need for change to legislation or statutory requirements to implement any recommendations made as a result of the Inquiry.

In conducting the Inquiry, the Committee is requested to seek information from relevant organisations, the motor vehicle repair and insurance industries, Victoria Police and other Government agencies. In particular, the Committee is requested to examine vehicle roadworthiness and vehicle inspection systems in other Australian States and comparable overseas jurisdictions. The Committee is also requested to liaise with the Environment and Natural Resources Committee's Inquiry into the contribution of older vehicles to air pollution.

Submissions close on 3 Mav 1999

Further Information: Mr Barry Aitken, Committee Executive Officer 9651 3632

APPENDIX 2

– ANALYSIS OF CORONER'S DATABASE

Method

The coroners database was searched for the terms 'defect' and 'roadworthy'. Fatal crashes in Victoria for the years 1996 to 1998 involving a vehicle that had at least one defect were identified. 64 cases were initially identified from the data base. 10 of these files were not held at the coroner's office. Thus, 54 cases were investigated. Information was obtained by reading the files themselves at the coroner's office.

Of the 54 crashes, 3 were found to have defects that caused the crash, 15 had defects that contributed to the crash, and 36 had defects that did not contribute to the crash at all.

The defects that caused the crashes were as follows:

- the near side rear axle broke and the wheel assembly detached
- the steering wheel was not secured properly
- the drag link failed and caused a total and sudden loss of steering control

Of the crashes in which the defect contributed to causing the crash, 11 were due to worn tyres, 3 were due to faulty brakes and one crash was due to both worn tyres and faulty breaks.

Examples of crashes in which the defect did not play a role at all include a drunk pedestrian being run over in the dark (not seen by the driver), a drunk and speeding driver loosing control on a bend and hitting a tree, and a driver falling asleep and veering off the road and hitting a tree.

Incidence of defects in crashes

The incidence of defects contributing or causing crashes can be determined by comparing the number of cases with defects identified as causal (3 cases) or contributing (15 cases) factors with the pool of cases inspected.

A search of the Coroner's database identified that of the 1,185 fatal cases over the three year period from 1996 to 1998, 224 had inspections carried out by the AIS.

Thus, in 1.3% (3/224) of fatal crashes, a defect was identified as the causal factor in the crash and in 6.7% (15/224) of fatal crashes, a defect was identified as having contributed to the crash.

Overall, based on this Coronial data it would appear that defects play a role in around 8% of crashes.

It should be noted that the Coronial database does not record the existence of a Police Mechanical Inspection Section (MIS) report. It does record AIS investigations. Based on discussions with Mr Simon Jolly (Research and Information Coordination Group, Victorian Institute of Forensic Medicine) it would appear that in the Coronial database MIS reports are only received as part of an AIS investigation. Thus the exact number of cases inspected is not completely certain.

Coronial Database - Detailed summary for each of the 54 cases identified as having at least one defect.

The following tables set out for each case:

- vehicle model and year
- driver characteristics
- crash description
- contributing causal factors
- type of defect
- whether the defect caused, contributed to or had no effect on the crash

Information was obtained by manual review of each case file at the coroner's office and extracting the relevant information.

Crash no.	File no.	Year	Vehicle (incl. model and year)	Driver chars.	Crash Description	Contributing/ causal factors	Type of defect noted					Did the defect cause, contribute, or not contribute at all to the crash	Summary
							tyres/wheels	brakes	steering	suspension	other		
1	0100	1996	1983 Ford station wagon	20 yo male (stolen vehicle, disqualified driver).	Driver lost control of the vehicle and collided with trees.	BAC of 0.15, drugs and speeding.	Worn tyres.			Excessive wear on both front and rear suspensions.		Contributed to the crash. Possibly worn tyres reduced ability to regain control of the vehicle.	Contributed
2	0104	1996	1986 Kowasaki motorcycle	36 yo male.	Rider lost control of his motorcycle and collided with a roadside post. Deceased was rider of motorcycle.	Inexperienced rider, possibly reckless riding.	Worn front tyre.					Did not contribute at all.	No
3	0128	1996	1982 Holden Commodore station wagon	41 yo female.	Driver lost control of the vehicle and collided with a tree.	BAC of 0.2, speeding.	Worn front tyre.		Steering rack bushes worn, steering misalignment.	Front suspension towers leaking, rear suspension spring shackles worn.	Headlight lenses corroded.	Did not contribute at all.	No
4	0384	1996	1969 Toyota sedan	40 yo female.	Driver lost control of vehicle and crossed over onto the incorrect side of the road and collided with an oncoming vehicle. Deceased was passenger in child booster seat in the back seat.	Poor weather conditions, worn tyres.	Worn and mismatched tyres.		Worn steering idler arm.	Worn front suspension control arm bushes, worn stabiliser arm bushes, worn rear shackle bushes.	Rust in one panel.	Contributed to the crash. Worn tyres caused the car to lose control in combination with poor weather conditions.	Contributed
5	0924	1996	1975 VW Kombi van	56 yo female.	The vehicle veered off the road and hit a tree.	Drugs that made the driver drowsy, possibly fell asleep at the wheel.	Worn tyre.				Front bucket seat mounts worn and removed.	Did not contribute at all.	No
6	0991	1996	1978 Ford Cortina sedan	17 yo male, unlicensed.	Driver of the vehicle lost control and it hit a pole. Driver and one passenger were killed.	Inexperience, BAC of 0.16, speed.		Brake pedal had excessive travel.		Rear suspension shock absorber rubbers worn.	Excessive rust.	Did not contribute at all.	No
7	1042	1996	1978 Ford Falcon sedan	55 yo female.	Driver suffered a stroke and collided with a pole.	Driver suffered a stroke.	Tyre worn.			Worn tie rod end.	Loose front spring saddles, rust in rear panels.	Did not contribute at all.	No
8	1162	1996	1956 Jaguar sedan	49 yo male.	Vehicle veered off the road and hit a pole. Deceased was driver of vehicle.	Inattention to driving, and possible drowsiness.	Worn tyres.	Brake arm of self-adjusting mechanism was disconnected.				Did not contribute at all.	No

Crash no.	File no.	Year	Vehicle (incl. model and year)	Driver chars.	Crash Description	Contributing/ causal factors	Type of defect noted					Did the defect cause, contribute, or not contribute at all to the crash	Summary
							tyres/wheels	brakes	steering	suspension	other		
9	1379	1996	1980 Holden Gemini sedan	20 yo female.	Driver lost control of the vehicle at a right hand bend. She traveled onto the incorrect side of the road and collided with an oncoming vehicle. It was raining and the road surface was wet and slippery. Deceased was driver of first vehicle.	Worn tyres, road conditions.	Worn nearside rear tyre.					Contributed to the crash. Worn tyre may have contributed, in combination with the weather conditions.	Contributed
10	1820	1996	1976 Crysler sedan	41 yo male.	Driver lost control of his vehicle and hit a tree. Deceased was driver.	BAC of 0.24.		Handbrake not operating.	Steering idler arm and tie rod ends were excessively worn.	Front suspension ball joint and stabiliser bushes excessively worn.	Excessive rust in the A pillars.	Did not contribute at all.	No
11	2325	1996	1981 Mazda station wagon	50 yo female.	Vehicle left the carriageway at a left curve and hit a tree. The road was wet.	Temporary lapse of concentration due to stress (possibly).						Did not contribute at all.	No
12	2349	1996	1971 Ford Falcon sedan	31 yo male.	Driver of car lost control of vehicle at a bend in the road. The vehicle then struck two trees and was torn apart.	Speed, reckless driving, possible cannabis involvement.	Worn and mismatched tyres.	Oil contaminated disc pad.			Rust in subframe, sills and offside rear wheel arch, rear axle weeping oil.	Did not contribute at all.	No
13	2360	1996	1979 Holden Commodore sedan	28 yo female.	Driver was travelling on wrong side of road. When attempting to correct for this, she lost control of the vehicle and stuck another vehicle. Conditions were fine. Deceased was driver of first vehicle.	BAC of 0.15, possible involvement of cannabis, speed, reckless driving.	Front tyres mismatched, worn tyres.		Excessive wear in the steering rack bushes.			Did not contribute at all.	No
14	2370	1996	1967 International van	36 yo male.	Driver lost control of the vehicle and the vehicle rolled over. Deceased was a front seat passenger.	The breaking of the near side rear axle, and subsequent detachment of the wheel assembly has resulted in the collision.' (senior constable)			Excessive freeplay in the steering wheel.		Rust in roof, wheel arch and lower side of the cabin and cabin floor, worn pitman shaft bush, battery not secured in the cradle.	Caused the crash. 'The breaking of the near side rear axle, and subsequent detachment of the wheel assembly has resulted in the collision.'	Caused
15	2390	1996	1981 Holden Commodore sedan	52 yo male.	The driver lost control of the vehicle, and was subsequently hit by two other cars.	Unknown, possibly speed.				Front suspension strut was leaking.		Did not contribute at all.	No

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							tyres/wheels	brakes	steering	suspension	other		
16	2486	1996	1978 Holden utility	19 yo male, probationary license.	The driver lost control of the vehicle and hit a telephone pole. Deceased was passenger.	BAC of 0.144, speed.		Brake hydraulic fluid vapour lock below standard, front disc rotors below minimum thickness and hot spots on the disc rotors, near side rear wheel cylinder leaking hydraulic fluid onto the brake shoes, drum and backing plate.				Did not contribute at all.	No
17	3400	1996	1977 Holden utility	21 yo male.	Vehicle left the carriageway and hit a tree. Deceased was driver.	BAC of 0.18, speed.		Front disc pads has insufficient friction material.			Rust in side sill and body.	Did not contribute at all.	No
18	3459	1996	1975 Datsun sedan	26 yo male, disqualified driver.	Driver lost control of his vehicle at a right hand bend and collided with two trees. Deceased was the driver.	BAC of 0.18, speed.	All tyres had insufficient tread depth, mismatched rear wheels.	Contaminated brake linings, weeping rear side near cylinder.			Rust in sills and one panel.	Did not contribute at all.	No
19	3734	1996	1982 Holden Gemini sedan	21 yo male.	The Nissan was being chased by a 4WD at high speed. Whilst going through a red light, the 4WD hit the Nissan. The driver of the Nissan then lost control of the vehicle, and it hit a tree. Both the driver and front seat passenger of the Nissan were killed.	Speed, being aggressively chased.	Unknown.	Unknown.	Unknown.	Unknown.	Unknown.	Did not contribute at all.	No
20	3842	1996	1991 Mitsubishi van	17 yo male, learner driver.	Driver lost control of the vehicle and it hit a tree. Deceased was passenger of the car.	Lost control of car.	Tyres worn.					Did not contribute at all.	No
21	0492	1997	1979 Toyota Landcruiser 4WD	19 yo male.	Toyota veered onto wrong side of road and collided with an oncoming vehicle. Driver believed to have fallen asleep. Deceased is driver of other car. Conditions excellent.	Fatigue, driving on wrong side of road.				Lower shock bush worn.	Weeping rear axle seal.	Did not contribute at all.	No

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22	0561	1997	1981 Ford Fairmont sedan	57 yo male.	Deceased was overtaking a vehicle on a Highway, lost control of his vehicle, and crashed sideways into a tree. Road was wet, it was raining. There was an amount of oil on the road in the vicinity where the deceased lost control of the vehicle.	Weather and road conditions, worn rear tyres.	Both rear tyres had insufficient tread depth.					Contributed to the crash. May have contributed, depending on the circumstances and road surface condition at the time.	Contributed
23	0963	1997	1984 Toyota Hi Lux utility	19 yo male, held probationary license.	The vehicle left the right hand side of the track on which it was travelling, and then rolled over the embankment. Deceased was driver of the vehicle. Fairly good road conditions.	Age and inexperience of driver, poor road conditions, alcohol, inattention to the road.	Worn tyre.	Contaminated brake linings, leaking wheel cylinder.				Did not contribute at all.	No
24	0998	1997	1986 Commodore sedan	29 yo male.	Driver lost control of the vehicle at a right hand sweeping bend. The vehicle slid forward onto an embankment, spun 180 degrees and flipped.	BAC of 0.15.				Shock absorber weeping and McPherson strut upper mounting bolt missing.		Did not contribute at all.	No
25	1444	1997	1989 Mazda coupe	37 yo male.	Driver lost control on a left hand bend on a highway. The vehicle spun around and hit a pole. Deceased was driver. Road surface was wet. Light rain falling.	Unknown, worn tyres may have contributed.	Worn tyres.					Contributed to the crash. May have contributed, depending on the road surface at the time.	Contributed
26	1461	1997	1985 Nissan sedan	18 yo male, held probationary license.	Pedestrian trying to flag down a vehicle was hit by a vehicle. He was standing in the left hand carriageway facing oncoming traffic. It was dark. Deceased was pedestrian.	Pedestrian standing in line of traffic.	Rear tyre has insufficient tread depth.					Did not contribute at all.	No

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27	1745	1997	Nissan Pintara station wagon	30 yo male.	Poor visibility due to fog. The driver moved over to the incorrect side of the road in order to overtake another car, and collided head-on with another car. The deceased was the driver of the Nissan.	Possibly drugs.	Unknown.	Unknown.	Unknown.	Unknown.	Unknown.	Did not contribute at all.	No
28	2787	1997	1991 Holden Commodore sedan	20 yo female.	The driver lost control of the vehicle on a gravel shoulder and has attempted to correct the vehicle, lost control and slid sideways towards an embankment, flipped over and struck a tree. Road and weather conditions fine. Deceased was driver of the car.	Possibly fell asleep at the wheel.		Insufficient brake pad thickness and a scored disk on the rear brake assembly and the front discs requiring machining.				Did not contribute at all.	No
29	2888	1997	1982 Harley Davidson motorcycle	37 yo male.	The driver of the motorcycle kicked the door of a car as he was driving at 100 km/hr. He lost control and flew over the handlebars. Deceased was the driver of the motorcycle.	Driver of motorcycle kicking the door of car while driving at 100 km/hr.		Insufficient brake pad thickness, scored front and rear discs.			Excessive exhaust noise.	Did not contribute at all.	No
30	2956	1997	1990 Suzuki motorcycle	23 yo male.	The driver lost control of his motorcycle when oil discharged from the vehicle's sump onto the road surface in line with the rear wheel. The bike dropped to the road surface and the rider slid across the centre of the carriageway and into the path of a moving vehicle. Deceased was the rider of the motorcycle.	Motorcycle sump plug working loose.	Worn tyres.					Did not contribute at all.	No
31	2977	1997	1979 Holden	29 yo male.	The driver lost control of the vehicle, crossed both sides of the road, became airborne and came to rest in small roadside trees and shrubs. Deceased was the driver of the vehicle.	BAC 0.09, steering wheel not secured properly.	Worn tyres, and front wheels fouled the bodywork of the vehicle.		Steering wheel was not secured to the column with the correct nut.			Caused the crash. The steering wheel not being secured properly may have had some involvement in the collision.	Caused

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32	3151	1997	1981 Commodore	21 yo male.	Pedestrian hit by vehicle. Deceased was pedestrian. High wind day, but conditions fine.	Speeding through roundabout, neither driver or pedestrian seeing each other.	Long list of defects.	Long list of defects.	Long list of defects.	Long list of defects.	Long list of defects.	Did not contribute at all.	No
33	3161	1997	1992 Kawasaki motorcycle 250cc	20 yo male, learner rider.	Driver lost control of motorcycle when trying to negotiate a sweeping left hand bend. He slid across the road and collided with the guard railing on the opposite side of the road. Deceased was the driver of the motorcycle. Weather and road fine.	Speeding, unroadworthy vehicle, and inexperience of the driver.	Worn tyres.					Contributed to the crash. May have contributed to the collision, depending on weather and road conditions at the time.	Contributed
34	3259	1997	1972 Mazda 808 sedan	47 yo female.	Vehicle failed to take a bend in the road and collided with a tree. Deceased was driver of the car.	BAC of 0.26, possibly fell asleep at the wheel.	Rear tyres had insufficient tread depth.	Hand brake had excessive travel.				Did not contribute at all.	No
35	3409	1997	1981 Yamaha motorcycle	27 yo male.	Driver attempted to overtake another vehicle and lost control of the motorcycle on the tram tracks. The motorcycle then dropped to the road surface with the deceased sliding across the centre of the carriageway and into the path of an oncoming vehicle. It was raining, the roads were wet. Deceased was driver of the motorcycle.	Slippery (wet) tram tracks, driving on wrong side of the road.	Worn rear tyre.					Did not contribute at all.	No
36	3498	1997	1982 Mazda van	18 yo female, learner driver.	Pedestrian walked onto road and was struck by car. Deceased was the pedestrian.	Pedestrian walked onto roadway quickly, a number of drugs found in blood of driver.	Worn tyres.				Muffler burnt out.	Did not contribute at all.	No

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37	3532	1997	1997 Ford sedan and caravan	36 yo male.	Vehicle (Ford) went onto incorrect side of highway and struck a Prime mover towing a semi-trailer. Deceased was passenger in the Ford. The car (Ford) and caravan appeared to be fishtailing prior to the crash. Weather conditions fine. Caravan was overloaded with weight.	Condition of tyres and brakes, driving on wrong side of the road.	Tyre walls cracking.	Poorly adjusted brakes.				Contributed to the collision. The ineffective brakes would have reduced the braking effectiveness of the vehicle and caravan combination. The ineffective caravan brakes may have caused the vehicle to sway and possibly jackknife when the brakes were applied. This directional instability may have contributed to the collision depending on the circumstances immediately prior to the collision.	Contributed
38	0020	1998	1981 four wheel drive Range Rover	Female.	Vehicle lost control and collided with a power pole, and rolled over.	Condition of the road and speed.	Worn tyre.	Oil contaminated rear brake assembly.			Axle seal leaking.	Contributed to the crash. The offside rear tyre being devoid of tread may have contributed due to the vehicles reduced traction on the unsurfaced road.	Contributed
39	0077	1998	1991 Holden Commodore Sedan	21 yo male.	Driver failed to correctly negotiate a left hand bend in the road, crossing onto the incorrect side of the road and colliding head on with a station wagon. Deceased were a number of people in the station wagon.	Possibly fell asleep at the wheel.		Brake disc was scored.				Did not contribute at all.	No
40	0645	1998	Datsun 200B (unregistered)	16 yo male, unlicensed.	Driver lost control of the vehicle and collided with a tree.	Age and inexperience of driver, poor road conditions.	Wheel and tyre of incorrect size fitted, one wheel not secured effectively.	Rear wheel cylinders weeping fluid.			Rust in rear, front seat belt not secured properly, burnt out rear muffler.	Did not contribute at all. (although the incorrect size and incorrect securing of one wheel would have resulted in handling instability.)	No

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							tyres/wheels	brakes	steering	suspension	other		
41	0748	1998	Harley Davison motorcycle (VV 017)	25 yo male.	While attempting to negotiate a right hand bend, the driver lost control of the motorcycle and left the roadway, travelling onto and along the grass and turning over several times. Very windy conditions. Dry road. Deceased was the driver.	Unknown.	Worn tyres.					Did not contribute at all.	No
42	0957	1998	Ford sedan (MS 0771)	26 yo female.	Vehicle veered to the left and hit a large rock embankment before coming to rest on its roof. Road was wet and slippery and it had been raining. Deceased was child in back seat.	Speeding.	Worn tyre.			Coil springs had been shortened by cutting, worn drag link and idler arm.		Contributed to the crash. The worn tyre may have contributed given the weather and road conditions at the time.	Contributed
43	1232	1998	Toyota Hi Lux 4WD dual cab utility	28 yo male.	Driver lost control when driving around a corner. In attempting to regain control, the vehicle slid along the road and rolled a number of times, landing on its wheels.	BAC of 0.16, vehicle defects.				Worn drag link ball joint.		Caused the crash. '…this drag link had failed by separating at the ball joint which connects the steering box pitman arm to the right hand stub axle. This appears to have occurred prior to the collision causing a total and sudden loss of steering control.'	Caused
44	1359	1998	Marmon prime mover (truck) (NWD 560), connected to a semi-trailer bulk bin	Male.	A driver of another car backed out of her driveway onto the path of this truck. There was thick fog, visibility very poor. Deceased was the driver of the other car.	Thick fog, car driven into path of the truck.	Unknown.	Unknown.	Unknown.	Unknown.	Unknown.	Did not contribute at all.	No
45	1518	1998	1990 Holden sedan	Male.	Drunk pedestrian lying on road was run over by car. Deceased was pedestrian. Visibility poor.	Person lay in road, poor visibility (dark).	Unknown.	Unknown.	Unknown.	Unknown.	Unknown.	Did not contribute at all.	No

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							tyres/wheels	brakes	steering	suspension	other		
46	1525	1998	1979 Toyota Corolla	18 yo male.	Vehicle drifted onto the left hand shoulder of the road and lost traction, then crossed onto the opposite shoulder and struck a tree in the drivers door. Deceased was driver. Road was wet. Some light drizzle, overcast.	Wet road, inexperienced driver.	Worn tyre.	Air in braking system, brake fluid contaminated, leaking wheel cylinders.			Rear friction material and rust in rear panels and dog legs.	Contributed to the crash. The condition of the rear brakes would have reduced the vehicle's braking capacity and the condition of the offside rear tyre would have had less traction on adverse road surfaces. These factors may have contributed to the collision.	Contributed
47	1532	1998	Holden Commodore (EQV 064)	67 yo male.	The car hit a rut and then traveled onto the incorrect side of the carriageway and struck another vehicle head on. Deceased was the driver of the other vehicle. The roadway was wet.	Road surface, travelling on incorrect side of carriageway.	3 worn tyres.					Contributed to the crash. The condition of the nearside front tyre may have contributed taking into account the weather and road conditions, and the vehicles movements immediately prior to and at the time of impact.	Contributed
48	1705	1998	Mitshubishi Colt sedan (NXA 171)	23 yo female.	Approached sweeping right hand bend at excessive speed, oversteered, lost control of the vehicle, it traveled on to the wrong side of the road and collided sideways with a power pole. Deceased were driver and front seat passenger.	BAC of 0.04, excessive speed.	Both front tyres lacked serviceable tread depth.					Did not contribute at all.	No
49	2019	1998	1974 Holden Torana	27 yo male.	Driver lost control of vehicle and struck a light pole. Road was wet, weather conditions unfavourable. Deceased was the driver.	BAC of 0.22, and condition of car.	Both front tyres devoid of tread.	Wheel cylinder was weeping hydraulic fluid.		Tie rod end was worn.	Rust.	Contributed to the crash. Faulty tyres possibly contributed, depending on road conditions. Rust may have increased the severity of the crash by weakening the structural integrity of the vehicle.	Contributed
50	2671	1998	Holden commodore	20 yo male.	Car struck pedestrian. Deceased was pedestrian. Visibility poor (dark).	Pedestrian walking out into moving traffic.		Ineffective handbrake.			Excessive exhaust noise.	Did not contribute at all.	No

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							tyres/wheels	brakes	steering	suspension	other		
51	2710	1998	Toyota lite ace van	27 yo female.	Car struck pedestrian. Deceased was pedestrian. Car was travelling at between 30-40km/hr.	Pedestrian walking out into moving traffic.	Uneven tyre wear.			Front end of vehicle required alignment.		Did not contribute at all.	No
52	2762	1998	motorcycle with pillion	Male.	The driver failed to negotiate a sweeping left hand bend, traveled onto the gravel shoulder and collided into a power pole. Deceased were the driver and 23yo pillion passenger.	BAC of 0.2, cannabinoides detected also, excessive speed.		Brakes inoperative due to rear master cylinder and foot peg bracket problems.				Contributed to the crash. May have contributed under heavy braking conditions.	Contributed
53	2916	1998	Yamaha 250cc trail bike	27 yo male.	The driver lost control on a slight right bend and collided with a concrete pole. Lighting was very poor. Deceased was driver.	BAC of 0.23 and cannabinoids detected, loosing control of vehicle.		Inoperative rear brakes.			Throttle did not return idle and no lighting fitted.	Contributed to the crash. Possibly contributed in these conditions.	Contributed
54	3276	1998	Holden station wagon	34 yo female.	The driver lost control of the vehicle (allegedly due to hail on the road surface), and the rear of the car skidded sideways to the wrong side of the road where it was hit by an oncoming vehicle and then collided with a letterbox. Weather conditions were atrocious, with heavy rain and hail. Visibility poor. Deceased was 8yo front seat passenger.	Weather conditions, loosing control of vehicle.	All tyres had insufficient tread depth.					Contributed to the crash. Possibly contributed, depending on other conditions at the time.	Contributed