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License to drive: Young drivers and nighttime curfews in Australia

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Abstract

Young drivers are over represented in nighttime crash statistics. In recent months in Australia, there has been an intense public debate about the necessity for action, and in particular, the desirability of the introduction of nighttime curfews.

Existing evidence has linked the introduction of curfews with reductions in crash rates in a number of jurisdictions around the world. In North Carolina for example, the introduction of a nighttime curfew has been linked with a 43 per cent reduction in nighttime crash rates (Foss, Feagnes and Rodgman, 2001).

There is strong opposition to curfews from some in community, particularly young people. Many people perceive curfews to be an infringement on their right to travel, and fear that curfews will severely hamper their ability to work, study and socialise.

Research in this paper questions whether curfews are necessarily linked with relatively low nighttime crash rates. Multivariate linear regressions were used to examine the involvement of 16 to 19 year old drivers in fatal crashes between the hours of 10:00pm and 6:00am. The analyses examined crash rates in 40 US states over a three year period, 1999 to 2001. The results of the regressions showed that, controlling for relevant variables including licensure rates and reference crash rates, the presence of a nighttime curfew in a state is associated with lower nighttime crash rates, though this association is not statistically significant. This result applied to all young drivers, as well as young male drivers and young female drivers.

LICENSE TO DRIVE:
YOUNG DRIVERS AND NIGHTTIME CURFEWS IN AUSTRALIA

Greg Smith

ABSTRACT

Young drivers are over represented in nighttime crash statistics. In recent months in Australia, there has been an intense public debate about the necessity for action, and in particular, the desirability of the introduction of nighttime curfews.

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There is strong opposition to curfews from some in community, particularly young people. Many people perceive curfews to be an infringement on their right to travel, and fear that curfews will severely hamper their ability to work, study and socialise.

Research in this paper questions whether curfews are necessarily linked with relatively low nighttime crash rates. Multivariate linear regressions were used to examine the involvement of 16 to 19 year old drivers in fatal crashes between the hours of 10:00pm and 6:00am. The analyses examined crash rates in 40 US states over a three year period, 1999 to 2001. The results of the regressions showed that, controlling for relevant variables including licensure rates and reference crash rates, the presence of a nighttime curfew in a state is associated with lower nighttime crash rates, though this association is not statistically significant. This result applied to all young drivers, as well as young male drivers and young female drivers.

This discussion paper is a revised version of a Policy Analysis Report written as part of the requirements for master in public policy, Australian National University.

1. INTRODUCTION

> *I know mums and dads across NSW worry when teenagers start getting on the road … and are worried sick that they might not come home.* (Carl Scully, NSW Roads Minister, SMH, 2004).
>
> *I object in the strongest possible terms to the proposal to impose a curfew on drivers under 21. This is a totally unacceptable infringement on the rights of young adults.* (Newman-Martin, SMH, 2004).

'Getting your P's' is an exciting time for most young Australians. The freedom to drive without supervision opens up new opportunities for work, study and socialising. In many ways, it represents an important step on the journey from being a teenager to an adult. But many people, among them the New South Wales Minister for Roads, Carl Scully, argue that the elevated crash rate of young drivers means that this freedom comes at too high a cost. Accordingly, in August 2004, the Minister announced his desire to introduce laws that would limit young people's driving freedom, a significant aspect of which would be a restriction on nighttime driving. This would be the first restriction of its kind in Australia.

For a nation that is usually apathetic about road safety[1], the public debate that arose from the Minister's announcement has been unusually intense. The debate has been spurred on by reports in the national media of a series devastating crashes involving young drivers.

Those arguing in support of the introduction of restrictions on nighttime driving – or nighttime curfews - are armed with compelling logic and evidence. The logic is simple: if young people cannot drive at night, they cannot crash. Those in favour of curfews argue that, if the time at which young people can drive alone at night is delayed, by the time they *are* allowed to drive at night, they will have developed the skills and experience necessary to cope with nighttime driving. The evidence links curfews with reduced crash rates. In North Carolina in the United States of America for example, the introduction of a nighttime curfew has been linked with a 43 per cent reduction in nighttime crash rates (Foss, Feagnes and Rodgman, 2001). Considering this, it is perhaps not surprising that 37 states in the US now have a nighttime curfew in place.

Though compelling, the logic and evidence tells only part of the story. There are strong arguments against the introduction of curfews. For example, when asked of his opinion recently, former NSW Chief Justice Sir Laurence Street put it bluntly: "The word curfew is redolent of a repressive, scattergun exercise in community regulation. Why should the rights of the many be curtailed in attempting to curb the excesses of a few (no doubt predominantly males)?" (Street, 2004; parentheses in original).

This line of argument rings true with those most likely to be affected by curfews – young people. They fear that their ability to work, study and socialise would be severely hampered by curfews. Some argue that curfews represent a trend of restrictions on the rights of young people which "combined with economic conditions … is forcing young people to remain dependent on their families, if they have one, for … longer [periods] of time" (Malloy, 2004).

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[1] See for example, Australian Automobile Association, 2004.

The potential difficulties in administering nighttime curfews also add to the complexity of the debate. One such difficulty is compliance. To be effective, laws must to a large degree, be self-enforcing. Thus, they need to "codify generally accepted principles for human behaviour in social contexts" (Foss and Goodwin, 2003). This principle is particularly important in this debate, since the ability of police to identify young drivers at night, and therefore enforce curfews, could be very limited.

Surveys of licensed drivers' attitudes and opinions provide an insight into the level of community support for curfews. In the USA, 67 per cent of drivers aged 17 and 18 in New York reported that they favoured "some kind of night driving curfew for beginning teenage drivers", and 80 per cent of drivers of the same age in Pennsylvania agreed (Williams, 2003). 90 per cent of parents of 15 year old drivers in Florida said that they were in favour of curfews (IIHS, 1995). Williams (2003) suggests that in the USA, young people do not necessarily like the concept of nighttime curfews which apply solely to them, but they do understand the rationale for curfews, and therefore adapt to them over time.

Nevertheless, compliance with nighttime curfews is not a given. For example, in Nova Scotia, Canada, 40 per cent of teens report having violated the nighttime curfew, and 12 to 15 per cent report having done so often (Mayhew, Simpson, Ferguson and Williams, 1998; and Williams, Nelson and Leaf, 2002). However, Williams (2000) contends that while compliance with curfews might not be absolute, even partial compliance will yield significant reductions in crash rates.

The crash rates of young drivers present a difficult ethical dilemma for governments. Young drivers are over-represented in crash statistics, particularly in nighttime statistics, such that governments, arguably, have a moral imperative to act. In the form of nighttime curfews, they are presented with a 'silver bullet'; a supposed surefire way of saving lives. On the other hand though, curfews don't come without their own costs—namely a reduction in the freedom of young drivers, and also increased administrative and enforcement costs.

The objective of this policy analysis report is to contribute to the debate about nighttime curfews by examining the evidence of links between curfews and crash rates, using data from the US. In contrast to Australia, the USA has many nighttime curfews already in place, and therefore is a good source of data on this topic. The report employs a series of multivariate linear regressions on data from a sample of 40 states to examine the relationship between crash rates and nighttime curfews for young drivers. Unlike a number of recent studies which have focused on single states, this type of cross-jurisdictional study is able to provide an insight into the effectiveness of curfews on a broad level. The hypothesis tested in this report is that the presence of a nighttime curfew is associated with lower nighttime crash rates for (a) young drivers, (b) young male drivers and (c) young female drivers.

The findings reported herein challenge the assumption that introducing nighttime curfews necessarily leads to lower crash rates. The regression analyses show that while the presence of a nighttime curfew is associated with lower nighttime crash rates, this association is not statistically significant. This suggests that while nighttime curfews have been shown to be effective in some states, there may be others in which curfews are poorly designed and therefore less effective. The results may also suggest that there are viable alternatives to nighttime curfews.

2. BACKGROUND

2.1. CRASH RATES

In the past 30 years, substantial progress has been made in making Australia's roads safe. In 1970, 3,798 people were killed on the roads, though by 2003 this figure had reduced by 57 per cent to 1,628 (Federal Office of Road Safety (FORS), 1998; ATSB, 2004). This reduction is particularly impressive given that the number of registered vehicles increased by more than 85 per cent during the same period (Australian Bureau of Statistics (ABS), 1982 and 2001). Nevertheless, the numbers of people killed and injured on Australian roads remains significant, and within road trauma statistics, young people are over represented.

In New South Wales, people under the age of 20 represent around 7 per cent of the population, but account for nearly 18 per cent of all road crash fatalities, and 25 per cent of fatalities at night (Nicholls, 2004). According to the Queensland Parliamentary Travelsafe Committee (Travelsafe), drivers and riders aged between 17 and 19 hold only 3.5 per cent of licenses, yet were involved in 13.6 per cent of reported crashes (Travelsafe, 2003). As an indication of the situation nationally, crash rates per 100,000 population, classified by driver age, gender and time of day are shown in Figure 1. Consistent with the NSW and Queensland statistics, it can be seen that the crash rate for young drivers is significantly higher than that of other drivers. Figure 1 also illustrates the fact that the crash rates of young males are higher than both the overall and nighttime crash rates of young female drivers. Overall, of the 767 drivers killed in road crashes in 2002, 118 were under the age of 20 (ATSB, 2004).

[Figure 1 about here]

It is common practice to analyse crash rates on a per population basis, not only because this controls for differences in populations of the groups being compared, but perhaps more importantly, population data is readily availability. However, comparisons on this basis can ignore the possibility that the exposure rates of different groups might vary. As the McDonald (1994) points out, "the quantity and quality of drivers' exposure to risk (distance driven, types of traffic environments) differs considerably between age groups in different ways in different places." It could be argued for example, that young drivers often crash at night simply because they often drive at night. This argument is supported to some degree by Williams (1985) who found that adolescents in the USA do more driving at night than other drivers, and that at every age, male drivers do more of their driving at night than female drivers.

The most common way to control for exposure is to standardise crash rates by distance travelled. However, unlike population data, this type of data is difficult to collect and therefore not readily avaiable for most groups of drivers. Given this limiting factor, exposure is often estimated by using data on the number of licensed drivers, which is propbably a better indicator than population data alone (see for example, Begg and Stephenson, 2003). This technique has been used to produce Figure 2, which plots fatal crash rates per 100,000 licensed drivers in NSW for 2001.

As can be seen, Figure 2 is generally consistent with Figure 1 – the crash rates of young drivers are noticeably higher than those of other drivers (with drivers over the age of 80 being the exception in this case). Indeed, McDonald (1985) found that the relationships shown in Figures 1 and 2 are consistent with other Australian and international studies that take account of actual distance travelled, which indicate that "crash risk is highest for young drivers, at a minimum for those in middle age, and rises again for older drivers".

[Figure 2 about here]

Figure 2 also shows the total number of fatal crashes for each age group. Notably, drivers aged between 20 and 39 have the highest propensity of fatal crash involvement, and drivers aged 80 plus have the fewest fatal crashes, despite having a very high crash rate.

2.2. GRADUATED DRIVER LICENSING AND NIGHTTIME CURFEWS

Motor vehicle crashes are complex events, usually the result of interactions between three categories of factors: human, vehicle and road. In a study of more than 15,000 crashes in the USA, it was found that human factors, which include the actions of the driver (such as speeding) and condition of the driver (such as the effects of alcohol, inattention and age) were a definite or probable cause in about 93 per cent of crashes (GAO, 2003). It is these human factors, and in particular, those associated with the age of a driver, which nighttime curfews are designed to address.

It is necessary at this stage of the report to clarify some of terms used herein. First is that, unless otherwise stated, nighttime curfews refer specifically to restrictions on driving, as opposed to general curfews which are designed to keep young people off the streets at night. Second, young drivers are, by definition, novice or new drivers. However, the reverse is not true: novice or new drivers are not always young. This report focuses solely on curfews on young drivers.

Nighttime curfews are more often than not a component of a broader licensing policy, typically known as Graduated Driver Licensing (GDL). GDL has become the most prevalent form of licensing for young drivers in western nations, with for example, Australia, New Zealand, Canada and the USA all having some form of GDL program in place. While the components of GDL programs tend to vary between states and countries, the common thread is that they "gradually introduce new drivers to more complex traffic environments as they gain experience" (Travelsafe, 2003). According to Whelan and Senserrick (2003), GDL works on four key levels, by:

- maximising the driving experience and maturity of the young driver by increasing the "restricted" licensing period;
- allowing young drivers to acquire experience by driving in low risk situations;
- encouraging practice by having regular tests; and
- rewarding safe driving and punishing illegal driving.

GDL programs are generally composed of three licensing levels: the "learner" stage, during which driving is supervised by a full license holder; the "intermediate" stage, which allows unsupervised driving though is subject to various restrictions; and the "full" license stage, which is achieved on successful competition of the two prior stages. The focus of this report is on nighttime curfews that apply to "intermediate" license holders. Throughout the report, the term "intermediate" is used, although several equivalent terms are actually used by various jurisdictions.

The concept of nighttime curfews is structured around two key characteristics of young drivers: inexperience and immaturity (NHTSA and IIHS, date unknown). Teenage years are often associated with experimentation, impulsiveness and risk taking. These traits sometimes lead to young drivers over-estimating their own abilities and under-estimating the risk associated with the roads. Young drivers also often do not have the skills and judgment needed when they face risky situations. Young drivers frequently travel during the high-risk nighttime hours, often with peers in the vehicle. Curfews are designed to allow young drivers to develop the necessary skills and judgment in low risk situations, prior to taking on the higher risk situations.

Like the USA, which is generally the point of reference in this report, legislative responsibility for driver licensing in Australia rests with the State and Territory Governments. The Federal Government's role in road safety is limited to one of coordination through the Australian Transport Council, of which the State and Territory, and Federal road ministers are members, and the National Road Safety Strategy. Despite the existence of the strategy, the states do tend to operate quite independently of one another – indeed each state has its own safety strategy, which does not necessarily align with the National Strategy.

There is at least one consistency between the States and Territories in Australia however, and that is that all have adopted some form of GDL, and none has adopted a nighttime curfew on young drivers, despite most having considered it at some stage (see for example Nicholls, 2004; Travelsafe, 2003; and King, 2004). A minor exception to this is that in Victoria, intermediate license holders who are returning to driving after suspension of their license are limited to one passenger only (Travelsafe, 2003).

A key difference between Australian GDL programs and those of the USA is the presence of nighttime curfews. By 2004, 37 states in the USA had introduced a curfew on intermediate drivers. The curfews generally restrict intermediate license holders from driving between the hours of 10pm and 6am for at least the first six months of licensure, though there tends to be some variation between the details of each states' policy. Some of the implications of these differences are discussed later in this report.

There are a number of arguments as to why Australian governments have not followed the lead of US states in implementing nighttime curfews. One of the leading arguments relates to the slightly different philosophies of the governments of each country. In Australia, the states seem to have taken a more 'probationary' approach to GDL, preferring to use techniques such as increasing the minimum age of licensure, rather than banning certain types of driving altogether (Williams, 2000). The opposite is true of the US. In the USA, an intermediate license can generally be obtained by the age of 16, whereas in Australia, the typical age is 17 (IIHS, 2004; Whelan and Senserrick, 2003). It is often argued that older drivers in Australia have greater need for work and study related travel than their younger US counterparts, and therefore a nighttime curfew would have a greater negative impact here than in the US.

3. THE LINK BETWEEN CURFEWS AND CRASH RATES

This section of the report examines evidence of links between curfews and crash rates, using data from the US. It begins with a review of existing research and is followed by the reporting of the results of a series of multivariate linear regressions on data from a sample of 40 states.

3.1. EXISITING RESEARCH

There is a body of research that examines the relationship between nighttime curfews and crash rates. Any early example of such research is that of Preusser, Williams, Zador and Bloomberg (1984), who examined the nighttime crash involvement of 16-year-old drivers in four states: Louisiana, Maryland, New York and Pennsylvania. The authors estimated the crash involvement of 16-year-old drivers without curfews using linear regressions on crash data from age groups not affected by curfews, and then compared these rates with actual rates. The results showed reductions in the rate of involvement of 16-year-old drivers in each of the four curfew states, with a decline of 69 per cent in Pennsylvania, 62 per cent in New York, 40 per cent in Maryland and 25 per cent in Louisiana.

These results should be treated with caution however. As Hatcher and Scarpa (2001) point out, the sample of control states was very small, with for example, New York and Pennsylvania being compared to Ohio only. They also point out that Preusser et al. (1984) did not control for a number of other factors that might influence crash rates, and the results therefore may be spurious. Lin and Fearn (2001) expand on this issue, noting that one of the main reasons that the actual involvement of 16 year old drivers in crashes in curfew states was lower than the predicted involvement, was because in three of the four curfew states the licensure rate was lower than that of the control states. That is, the lower than expected crash involvement could have been because, on a population basis, there were fewer licensed drivers.

Research has also linked general nighttime curfews that are designed to keep young people away from public places, as opposed to restricting driving specifically. Preusser, Zador and Williams (1990) for example, examined the relationship between general curfews and fatality rates of 13 to 17 year olds in 149 cities in 32 states. They reported a 23 per cent reduction in nighttime fatalities for 13 to 17 year olds for cities with curfews (Lin and Fearn, 2001). However, this reduction in the fatality rate of young people does not necessarily imply that the crash rate of young drivers is lower in those cities that have curfews. "Fatalities" can also include non-driver deaths such as, passenger, pedestrian and cyclist deaths.

In more recent years, research has tended to focus on the examination of the impact of Graduated Driver Licensing in a single state, as opposed to more broad cross-jurisdictional examinations. For example, Ulmer, Preusser, Williams, Ferguson and Farmer (2000) compared the crash rates of young drivers in Florida before and after the introduction of a GDL program, which included a nighttime curfew. To do this, the authors calculated crash rates per 10,000 population for 15, 16, 17 and 18 year old drivers for the years 1995 (prior to GDL) and 1997 (after GDL). By standardising crash numbers by population data, population growth between 1995 and 1997 was controlled for. These crash rates were then divided by the crash rates of 25 to 54 year old drivers, who represented a 'reference group'. By using this reference group, general crash trends, which "might reflect economic factors, special traffic safety initiatives, or varying levels of enforcement", were controlled for (Foss et al., 2001).

Having determined the crash ratios, Ulmer at al. (2000) then tested the significance of the change in the 1997 ratio compared to the 1995 ratio for each age group. The authors also carried out the same process for crash rates in neighbouring state, Alabama, which did not have any GDL program in place, and therefore represented a control group. Ulmer et al. (2000) found that as a result of the introduction of GDL, there was a 9 per cent decline in crash rates of 15 to 17 year old drivers, though there was not a significant decline for 18 year olds. The reduction in crash rates was found to be more pronounced for nighttime crashes than daytime crashes. Conversely, the crash rates of the same age groups in Alabama, which did not have a GDL program, did not decrease significantly.

While Ulmer et al. (2000) did not take licensure rates explicitly into account in their analysis, they did note that there was an increase in the number of young licensed drivers between 1995 and 1997. For example, there was a 29 per cent increase in the number of licenses issued to 15 year olds between 1995 and 1997. The authors suggest that this increase makes the declines in crash rates all the more impressive. However, the fact that they did not take licensure rates into consideration when analysing and comparing to the Alabama crash rates is potentially important. It is difficult to conclude that Alabama did not also experience a significant change in crash rates if this variable is not taken into account.

Following the methodology of Ulmer et al. (2000), Foss et al. (2001) and Shope, Molnar, Elliott, and Waller (2001) examined the relationship between crash rates and new GDL programs in North Carolina and Michigan respectively.

In the case of the North Carolina study, Foss et al. (2000) examined population based crash rates of 16 year old drivers for the two years prior to the introduction of GDL, 1996 and 1997, and for the year after the introduction, 1999. The crash rates of 25 to 54 year old drivers were used as a reference group. The results showed that crash rates declined sharply after the GDL program was introduced, with 16-year-old crash rates declining by 23 per cent between 1996 and 1999, and fatal crashes declining by 57 per cent (from 5 to 2 per 10,000 population). Nighttime crashes were said to be 43 per cent less likely to occur.

Foss et al. (2001) also analysed crash rates on a per license basis, though did not report their results. They noted that it was difficult to interpret the licensed based crash rate results because in 1999 the state was still in a period of transition between licensing systems and therefore the types of licenses held by 16 year olds was much more diverse than in previous years. They did note however, that licensed based crash rate did decline after the introduction of the GDL program, though the decline was less pronounced than that of the population based crash rates.

In the Michigan study, Shope et al. (2001) found that the risk of 16-year-olds being involved in a crash was 25 per cent lower in 1999 (after the introduction of the GDL program) than it was in 1996, and the risk of being involved in a crash at night declined by 53 per cent. Notably, while the risk of being involved in a fatal crash declined by 26 per cent, this result was not statistically significant, which the authors suggest was likely to have been because of the small number of fatal crashes being examined (Shope et al., 2001).

As in the previous studies, in examining the population based crash rates in Michigan, Shope et al. (2001), did not explicitly control for license rates. The authors acknowledged that the crash rate reductions could be partly explained by teens delaying licensure after the introduction of GDL. They noted that there was indeed a decline in the number of 16 year olds licensed to drive unsupervised between 1996 and 1999 – of 22 per cent. However, Shope et al. (2001) point out that the reductions in crash rates, particularly during the night, exceeded the decrease in license rates, and therefore remain significant.

Notably, unlike the Florida study, in the North Carolina and Michigan studies no comparison was made with the crash rates of other, 'control' states. Thus, the possibility that other states might have achieved similar improvements without the use of nighttime curfews cannot be ruled out from the results of these studies.

Overall, the findings of existing research has consistently been that Graduated Driver Licensing is associated with reduced crash rates, though the degree of reduction is not clear (Hartling, Wiebe, Russell, Spinola and Klasson, 2004). One of the reasons that the degree of reduction is unclear is that other factors, such as changes in licensure rates as a result of introducing GDL, are not always explicitly controlled for. Hence, it seems that results might be improved with the use of additional control variables. Also, recent studies have tended to focus on comparing pre and post GDL crash rates in a single state, and drawing comparisons with a limited number of, if any, control states. The existing research would be well complemented by a cross-jurisdictional study is able to provide an insight into the effectiveness of curfews on a broader level.

3.2. REGRESSION ANALYSES

One method of examining the relationship between nighttime curfews and crash rates, which appears not to have been employed in recent research, is to compare crash rates of a mixture of jurisdictions, some of which have nighttime curfews and some of which do not. Logically, given the existing research discussed above, whether a state has, or does not have a nighttime curfew, should be a significant factor in explaining the involvement of young drivers in nighttime crashes. In recent years, there appear to have been few studies of this cross-jurisdictional type reported. Most studies have tended to focus on comparing crash rates pre- and post- implementation of curfews in a single state.

Hence, the hypothesis to be tested in this study is that the presence of a nighttime curfew is associated with lower nighttime crash rates for (a) young drivers, (b) young male drivers and (c) young female drivers. Given that the crash rates of male and female drivers are very different, examining them separately will provide an insight into the question posed by Street (2004) in the introduction of this paper: whether curfews limit the freedoms of many to curb the excesses of a few (namely males). The need to examine the effects of the gender of a driver was also identified by Shope et al. (2001).

To test these hypotheses, linear multivariate regressions were used to examine panel data for US states over the period 1999 to 2001. The dependent variable is fatal crash involvement of young drivers, the key independent variable is the presence, or non-presence, of a nighttime curfew, and a range of variables which might influence crash rates were controlled for.

3.2.1. UNIT OF ANALYSIS

The analysis is of a sample 40 states in the USA, details of which are provided in Appendix 1. The sample includes states with, and states without, nighttime curfews, and some that introduced curfew during the period 1999 to 2001. Information on the states' curfew status was obtained from the IIHS (2004a, b), Williams (2003), and Ulmer et al. (2000).

All states which did not change their curfew status during the three year period were included in the sample. For those that did introduce curfew laws during this period, or in the year prior to 1999, then only states whose law took effect on the first day of the year were included. For example, Colorado, which introduced a nighttime restriction on 1 July 1999, was not included in this analysis.[2] This criteria was used so that periods in which the restrictions applied could be readily matched to the crash, license, population and other data, which are usually reported on an annual (calendar year) basis. This criteria also relates to the transitional effect of introducing a GDL, which is expanded on in the "Control Variables" section below.

This selection criteria gave a sample of 40 states. As the analysis examines crash rates over a three-year period, the sample size is 120 (40 states multiplied by 3 years).

3.2.2. DEPENDENT VARIABLE: CRASH RATES

The dependent variable in this study is referred to as the *crash rate,* defined as being the annual number of nighttime fatal crashes in which a "young" driver was involved, per 100,000 young people. The fatal crash data were obtained from US Department of Transportation's (DOT) Fatality Analysis Reporting System (FARS) and mid-year population data from the US Census Bureau using the Federated Electronic Research, Review, Extract, and Tabulation Tool (DataFerrett). There were three versions of this dependent variable used, each of which was tested separately. The first used crash and population data for male and female drivers, the second inlcuded data for male drivers only and the third, data for female drivers only.

The standardisation of crash rates by population figures is common in this type of analysis, as it controls for growth in population during the analysis period (see for example Foss et al., 2001 and Shope et al., 2001). This standardisation also increases the dispersion of the variable, which will create a more stable regression result.

For the purposes of this study, a "young" person is defined as being someone aged between 16 and 19 years old. This definition was used for two reasons. First, this is the smallest range of ages that the DOT uses for reporting the number of young people with driver's licenses. Hence, this definition of "young" allows the age groups for the license data (used as a control variable) and crash rate data to be matched in the regressions. Second, this age group generally represents the "treatment" group which nighttime curfews are designed to target. For states with a minimum intermediate licensure age of 16 for example, it seems reasonable to assume that a large proportion of young drivers will obtain their license at some stage between the ages of 16 and 19. This is consistent with the research of Begg and Stephenson (2003).

"Nighttime" was defined as being between the hours of 10:00pm and 6:00am because these hours generally cover the range of curfew operation times of the sample states.

[2] It might be possible to include data from these states by undertaking an unbalanced panel data analysis, though this refinement is beyond the scope of this report.

3.2.3. KEY INDEPENDENT VARIABLE: NIGHTTIME CURFEW

One way to estimate the effect that nighttime curfews have on crash rates is to use a dummy variable in the regressions. Thus, the presence or non-presence of a nighttime curfew is included in this study as a dichotomous variable where 1 indicates the presence of a curfew on intermediate license holders and 0 equals no curfew.

Table 1 below shows the number of states in the study that had a nighttime curfew in 1999, 2000 and 2001. It can be seen that in 1999, 16 of the 40 states had a nighttime curfew, and by 2001, this proportion had increased to 21 of 40.

[Table 1 about here]

While the hours during which restrictions apply vary from state to state, this aspect is not directly controlled for in this study. For example, a state that restricts driving between midnight and 5:000am was coded in the same way as a state that restricts driving between 10:00pm and 6:00am. As is noted in the "Crash Rates" section above, nighttime is defined in this study as being between 10:00pm and 6:00am, which generally covers the range of curfew operation times of the sample states. It might be possible to directly control for the variation between states through the use of further dummy variables, though this refinement is beyond the scope of this study.

3.2.4. CONTROL VARIABLES

Twelve additional independent variables were used in the regressions to control for factors that might influence variations in crash rates. A brief explanation of each is provided below.

TRANSITION YEAR

As was discussed earlier in the "Units of Analysis" section, states were selected for the study with the transitional effects of introducing a nighttime restriction in mind. As Foss et al. (2001) discuss, it is inevitable that in the early years of a GDL, there will be a mixture of old and new license types in an age cohort. In most GDL programs, it is not until 18 months after its introduction that the first 'full' license holders could begin to appear. It is generally not until 6 months after introduction that the first intermediate license holders, the subjects of this study, could begin to appear. This means that in at least the year of introduction, crash rates will reflect the driving of some young people that are subject to nighttime restrictions, and some that are not.

In recent research examining the impact of GDL programs in a single jurisdiction, it has been common to analyse data from years preceding the introduction and years at least one year after the introduction date. For example, in their study of crash rates in North Carolina, Foss et al. (2001) analysed data from 1996, 1997 and 1999. Data from 1998 was not analysed because it was the transition year, and therefore represented a mixture of license types.

In this study, which examines three consecutive years of data from a number of states, excluding transitional years would mean excluding states from the analysis, thus reducing the sample size. Rather than doing this, a dummy variable, named the *transition year*, has been included for those states that introduced a nighttime curfew during the 1999 to 2001 period. For example, Idaho introduced a GDL program, which includes a nighttime curfew for intermediate license holders, on 1 January 2001. In the analysis, the transition variable for Idaho is coded "1" for 2001, and "0" for 1999 and 2000. By using this variable, the sample size is maximised.

Notably, as discussed earlier, states that introduced a GDL program on a day other than the first of the year are not included in the study. The exceptions to this rule are the states of Tennessee and Washington, which introduced GDL programs on 1 July 2001. This is because, in each of these states, to obtain an intermediate license a driver must have held a learner license for at least 6 months. Therefore, by definition, neither of these states had intermediate license holders who were subject to nighttime curfews in 2001. Thus, the transition year variable for these two states in 2001 is coded "0". [3]

YEAR

Because this study examines crash rates over a three-year period, from 1999 to 2001, it is necessary to control for the possibility that variations are tied to the passing of the years. Two dummy variables are used, the first for the year 1999, and the second for the year 2000. The selection of these years, in preference to the year 2001, is arbitrary and has no impact on the results.

REFERENCE CRASH RATE

There is the possibility that variations in the involvement of young drivers in fatal crashes might be a function of some general crash rate trend. This issue was discussed in the "Existing Research" section of this report. In this study, the variable controlling for this relationship is referred to as the *reference crash rate*, and is defined as being the annual number of nighttime fatal crashes in which a driver aged between 25 and 54 was involved, per 100,000 licensed drivers of the same age group. Shope et al. (2001) note that this approach is somewhat limited by the fact that, to the extent that young drivers are involved in crashes with older drivers, fewer crashes among young drivers is likely to affect the crash rates of older drivers. They conclude however, that this approach is reasonable, and is consistent with other studies of this kind.

LICENSURE RATE

The need to control for licensure rates was highlighted earlier. The mechanism by which licensure rates influence crash rates is exposure. Numbers of licensed drivers is often used as a proxy for the distance travelled, or exposure, by a driver (see for example Begg and Stephenson, 2003).

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[3] The use of the "transition year" variable assumes that people who obtained their license prior to the introduction of a GDL program are exempt from its restrictions. This was the case in North Carolina. However, in Florida, existing license holders were subject to new nighttime curfews. Further research may be needed to refine this aspect of the models.

Hence, the number of "young" licensed drivers, standardised by the population of young people in a state, was included in the regressions as a control variable. This variable is referred to as the *licensure rate*. License data were sourced from DOT's TranStats database.

Importantly, three versions of this variable are used, depending on the dependent variable being tested. For the first dependent variable, crash rates of both young male and female drivers, data for young male and female licensed drivers and populations is used. For the regressions examining male crash rates, data for male licensed drivers and populations are used, and likewise for female crash rates.

RATIO OF MALE TO FEMALE LICENSED DRIVERS

Earlier, it was shown that on both a population basis and a license rate basis, crash rates for young male drivers were higher than that of young female drivers. Given this distinction, in addition to controlling for overall licensure rates, it is desirable to control for proportion of licensed drivers who are male or female. Other things being equal, it would be expected that a state with more male drivers than female drivers would have a higher crash rate relative to a state with fewer male drivers than female drivers. In this study, the ratio of 16 to 19 year old male drivers to 16 to 19 year female drivers controls for this factor.

MINIMUM LICENSURE AGE

In three of the sample states, Kansas, New Mexico and South Carolina, it is possible for young people to obtain an intermediate license before the age of 16. It is possible that some drivers in these three states will complete all or some of their nighttime curfew period before the age of 16. One such example is in New Mexico, where young people can obtain their intermediate license at 15 ½, and the nighttime curfews end after one year of licensure. While it is likely that not all people would obtain their license immediately upon turning 15 ½, it is nevertheless desirable to control for this characteristic.

RESTRICTIONS END

All of the states specify a time at which their nighttime curfews end. In some cases, restrictions end after a specified time after licensing. For example, in North Carolina restrictions end after 6 months of driving. Other states, such as Ohio, specify that restrictions end at a particular age, in this case 17. There are also states that use both measures, such as Nebraska, which has a nighttime restriction which ends after one year of driving or at age 18, whichever comes first.

Since the dependent variable refers to the crash rates of drivers aged 16 to 19, it is necessary to control for the fact that in some states, some crashes will be included in which the driver was, by definition, not subject to a restriction. To do this, a dummy variable is used for those states that define a maximum restriction age that is less than 19. For those states that set a minimum period and maximum age, such as Nebraska, the maximum age figure is used in this variable.

INCOME

While a person's income is not directly related to their risk of crashing, it might be a proxy for a factor that is. One such factor may be vehicle age. In a study examining the aging of the Australian vehicle fleet, Holgate (1997) reported that the rate of involvement of older vehicles is higher than that of newer vehicles. He also found that when a crash does occur, occupants are more likely to be injured or killed in older cars than newer ones. Holgate pointed out that "the affordability of vehicles is such that for some purchasers, a new vehicle is an impossibility" (Holgate, 1997). The implication of this is that people who cannot afford a newer car have a higher risk of being injured in a crash.

Hence, there is a need to control for the fact that some young drivers may be at increased risk of a being involved in a crash simply because they, or whoever owns the car they are driving, cannot afford a newer, safer car. To do this, the per capita personal income, which is related to a person's ability to purchase a car, for each state was included in the regressions as a control variable. This data was sourced from the US Bureau of Economic Analysis (BEA).

DISTANCE TRAVELLED

Although data on the distance travelled by young drivers at night is not available for the sample states, broader, state-wide total distance travelled data is. This data has been included in the model to control for the fact that, to the extent that total distance travelled data is representative of the distance travelled by young drivers, drivers in some states might travel further than those in other states, and therefore have a higher rate of exposure.

The data used for this variable is total vehicle miles travelled standardised by 100,000 population for each state in each year. The data was sourced from the DOT's TranStats database.

RATIO OF URBAN TO RURAL DISTANCE TRAVELLED

In their analysis of crash data for 2001, the United states General Accountability Office (GAO) reported that fatal crashes occurred more frequently on rural roads than urban roads (GAO, 2003). While rural roads in the USA carry around 40 per cent of traffic (measured in vehicle miles travelled), they experience more than 60 per cent of annual fatalities.

Thus, in addition to controlling for the total distance travelled in each state, it is necessary to control for proportion of driving that is done on urban and rural roads. In this study, the ratio of urban vehicle miles travelled to rural vehicle miles travelled is used for this purpose. This data was sourced from the DOT's TranStats database.

3.3. RESULTS

For each of the three dependent variables, two regression models were used. The first compared crash rates with each of the 12 independent variables, and the second compared crash rates with the nighttime curfew variable and only those variables which made a significant contribution to the first model. The results of each regression model, shown in Table 2, are discussed consecutively below.

[Table 2 about here]

3.3.1. YOUNG DRIVER CRASH RATES

In Table 2, Models 1 and 2 apply to the crash rates of young male and female drivers. For Model 1, there is a significant relationship between the crash rate and the other variables (F=4.300, p=0.000). From the adjusted R-squared value of 0.250 it can be seen that, allowing for chance, Model 1 accounts for 25.0 per cent of the variation in the crash rate.

Just two of the independent variables, the licensure rate and the reference crash rate have a significant impact on the model at the 95 per cent significance level (p=0.039 and p=0.023 respectively). The sign of the regression coefficient for the licensure rate is positive, as was expected. This implies that, holding the other variables constant, an increase in the licensure rate is associated with an increase in crash rate, confirming that licensure rate is a proxy for exposure.

The sign of the regression coefficient for the reference crash rate is also positive which, like the licensure rate variable, implies that, holding the other variables constant, an increase in the reference crash rate is associated with an increase in young driver crash rates. This too is probably to be expected. Intuitively, those states which experience a high number of 25 to 54 year old crashes are more likely to experience more young driver crashes than states which experience low numbers of 25 to 54 year old crashes.

The most critical feature of Model 1 is that the key independent variable, nighttime curfew variable, does not have a significant impact on the model (p=0.803). Notably, the regression coefficient is positive, which implies that, holding the other variables constant, an increase in the nighttime curfew variable is associated with a increase in the crash rate. Since this variable is dichotomous, with "0" indicating no curfew and "1" indicating the presence of a curfew, the positive coefficient implies that the presence of a nighttime curfew is associated with higher crash rates, though this association is not statistically significant. This relationship is not in line with existing research.

Conspicuous in their lack of significance are the remaining nine independent variables. While a detailed discussion of these variables is beyond the scope of this study, it nevertheless worthwhile briefly noting a few of the more interesting results. It was expected that the ratio of male to female licensed drivers would have a positive association with crash rates: the more males there are relative to females, the higher crash rates. However, as can be seen in Table 2, the regression coefficient is negative, which indicates the reverse, though this association is not statistically significant. One reason that this variable does not make a significant contribution may be because there tends to be relatively little variation in the ratio of male drivers to female drivers in the states.

It is interesting to note that per capita income does not make a significant contribution, though the sign of the regression coefficient is as expected – higher incomes relate to lower fatal crash rates. In an earlier discussion, it was postulated that income could be a proxy for the age of car that a person is likely to drive, which has been shown to be a risk factor for road crashes (Holgate, 1997).

It is also worth noting briefly the errors of prediction, or residuals, for Model 1. Figure 3 below plots the actual crash rates against predicted crash rates. The vertical distance between each point and the regression line identifies the difference between the actual and predicted crash rate (residual) for each observation. It can be seen that a number of the predictions were quite accurate, having a residual value of close to zero. Others had quite large residual values, indicating that the prediction for that observation was not good.

[Figure 3 about here]

Importantly, it appears that in cases where the actual crash rate was less than around nine fatal crashes per 100,000 population, the crash rate predicted by model tends to be over estimated. This is an indication that there might be an important variable which is specific to these observations that is omitted from the model. Future studies should investigate this issue.

Model 2 is a reduced version of Model 1, and examines just the nighttime curfew and those variables that were significant at the 95 per cent significance level: the licensure rate and the reference crash rate. It is interesting to note that the variables in Model 2 are the same as those examined in previous research (see for example Foss et al., 2001, and Shope et al., 2001). Thus, it is valid to exclude the non-significant variables in Model 1.

Table 2 shows that the adjusted R-squared value for Model 2 is 0.234, which is slightly higher than that of Model 1. This implies that Model 2, despite having fewer independent variables, has a better predictive power than Model 1. The impact of each of the three control variables is more significant in Model 2, though the nighttime curfew remained insignificant at the 95 per cent confidence level. In contrast to Model 1, the regression coefficient for the nighttime curfew is negative, implying that the presence of a curfew is associated with lower crash rates. This aspect is in line with existing research, though the fact that the curfew variable is not significant is not in line with the literature.

3.3.2. YOUNG MALE DRIVER CRASH RATES

In Table 2, Models 3 and 4 apply to the crash rates of young male drivers. For Model 3, there is a significant relationship between the crash rate and the other variables (F=4.946, p=0.000). From the adjusted R-squared value of 0.285 it can be seen that, allowing for chance, Model 1 accounts for 28.5 per cent of the variation in the crash rate.

With reference to the significance of the independent variables, the results for Model 3 are similar to those of Models 1 and 2: the licensure rate and reference crash rate variables have an impact at the 95 per cent significance level, and the other variables, including the nighttime curfew variable, do not. As was the case for Model 1, the sign of the nighttime curfew is positive. Unlike the first two models however, the ratio of urban to rural distances travelled variable is almost significant (p=0.056).

Model 4, being a reduced version of Model 3, also shows a similar result to Model 3. Removing the insignificant independent variables (but retaining the urban to rural distance travelled variable) results in an increase in the significance of the remaining variables, including the nighttime curfew variable, though it remains low (p=0.274). As was the case for Model 2, removing the insignificant variables results in the sign of coefficient of the nighttime curfew becoming negative.

3.3.3. YOUNG FEMALE DRIVER CRASH RATES

Models 5 and 6 apply to the crash rates of young female drivers. Table 2 shows that for Model 5, there was not a significant relationship between the crash rate variables and the independent variables (F=1.695, p=0.078).

Model 6 is reduced version of Model 5 which, for consistency with the previous models, controls for licensure rate and the reference crash rate. For Model 6, the relationship between the crash rate and the other variables is significant, though less so than that of the earlier models (F=3.647, p=0.015). From the adjusted R-squared value of 0.063 it can be seen that, allowing for chance, Model 6 accounts for just 6.3 per cent of the variation in the crash rate, which is much lower than that of Models 1 to 4. This implies that predicting female crash rates is more difficult that those of males or the male and female population combined.

In Model 6, the reference crash rate is the only variable that had a significant impact at the 95 per cent confidence level (p=0.004). The sign of the nighttime curfew is negative.

3.3.4. SUMMARY OF RESULTS

Based on these results, it can be concluded that, controlling for population, licensure rates, reference crash rates and, in the case of young male driver crash rates, the ratio of total urban distance travelled to total rural distance travelled, the presence of a nighttime curfew is associated with lower nighttime crash rates, though this association is not statistically significant. When a range of additional variables are controlled for, such as per capita income and the ratio of licensed male drivers to licensed female drivers, the significance of the nighttime curfew variable decreases. Compared to the models for all young drivers and for young male drivers, the young female drivers' models had poor predictive power.

Thus the hypothesis tested in this study: that the presence of a nighttime curfew is associated with lower nighttime crash rates, is rejected, at least with the data employed in this study. This finding is in contrast with existing research which, for the most part, presents a clear case for the implementation of curfews. For governments considering curfews, the existing research, in combination with the simple logic that if people cannot drive at night then they cannot crash at night, must be compelling. However, the findings in this report suggest that the case is not clear.

There are at least two possible explanations for the results obtained in this study. The first is that, although curfews have been shown to be effective in reducing crash rates in some states, they might not be effective in others. The literature suggests that this could indeed be the case. For example, Foss and Godwin (2003) argue that there are a number of Graduated Driver Licensing programs in the USA which are poorly structured such that they do not achieve their full potential. They suggest that one reason for this might be that nighttime curfews in some states begin too late to make a real difference to nighttime crash rates. Chen, Baker, Braver and Li (2000) found that fatal crash risks for 16 and 17 year old drivers is three times higher during the period 10:00pm to midnight than between 6:00am to 10:00pm, and Foss, Goodwin, Rodgman and Feaganes (2002) found that 16 and 17 year olds do only 3 per cent of their driving between midnight and 6:00am. Hence, a state which has a curfew that operates between say, midnight and 6:00am, potentially misses the most critical time for nighttime crashes. Additionally, as was discussed in the introduction of this report, compliance with curfews has been shown to vary, and enforcement is difficult. This might also affect the success of curfews, and therefore the results of this study might be a reflection of this factor.

The second possible explanation for the results in this study is that there are states which did not have curfews in place, but have nevertheless managed to maintain relatively low crash rates, possibly by some other specific means. While this research does not provide a specific insight into what these other means might be, it does suggest that curfews are not necessarily the only way to achieve relatively low nighttime crash rates.

Of course, there are also methodological factors that could influence whether or not the presence of a nighttime curfew is significant, some which are outlined here. The first relates to the fact that the definition of young people as being between 16 and 19 years old is somewhat broad, such that the significance the curfew variable might be lower than if a narrower definition were used. For example, Foss et al. (2001) and Shope et al. (2001) examined crash rates for 16 year olds, and Ulmer et al. (2000) examined rates for 15 to 17 year olds.

Having said that however, Begg and Stephenson (2003) define the "treatment" group for the Graduated Driver Licensing program in New Zealand as being those aged 15 to 19, and demonstrate significant reductions. Thus, the use of a relatively broad definition of "young" people is not without precedent. As noted earlier, limitations on the availability of data was a factor in defining "young" people.

Another methodological factor which might influence whether the presence of a nighttime curfew is significant is the type of crashes analysed. In this study, the focus was on fatal crashes, which represent only a small proportion of overall crashes. Other studies typically analyse a broader range of crashes ranging from those in which a person is killed (fatal) to those in which nobody was injured. It may be that the presence of a nighttime curfew does become significant when a broader range of crashes are assessed. A limiting factor was the availability of data.

Finally, as was discussed earlier, states which introduced a curfew on a day other than the first of the year were excluded because of difficulties in matching curfew periods with data which is reported on an annual basis. The inclusion of these states, and perhaps the analysis of a longer time period, might produce different results.

4. CONCLUSION

The crash rates of young drivers present a difficult ethical dilemma for governments. Young drivers are over represented in crash statistics, particularly in nighttime crash statistics. In 2003 alone, 113 drivers under the age of 20 were involved in a fatal car crash (ATSB, 2004).

In the form of nighttime curfews, decision makers a presented with a 'silver bullet'; a supposed surefire way of saving lives. Evidence from a number of studies examining the effectiveness of nighttime curfews is compelling. In the US state of North Carolina for example, the introduction of a nighttime curfew has been linked with 43 per cent reduction in crash rates (Foss et al., 2001).

However, there is strong opposition to curfews from some in community. Not surprisingly, this opposition is lead by those most likely to be effected by curfews – young people, who fear that their ability to work, study and socialise would be severely hampered by curfews. Others object to curfews on principle. For example, when asked of his opinion recently, former NSW Chief Justice Sir Laurence Street put it bluntly: "The word curfew is redolent of a repressive, scattergun exercise in community regulation. Why should the rights of the many be curtailed in attempting to curb the excesses of a few (no doubt predominantly males)?" (Street, 2004; parentheses in original).

The curfew debate is also complicated by issues of practicality. Compliance with curfews in the USA relies heavily on the assistance of parents of young people, since formal enforcement is difficult. The fact that intermediate license holders in Australia are typically older than those in the USA makes this issue all the more important. Exemptions which cater for the need to travel for work and study are possible, but undoubtedly present an administrative challenge.

Research in this paper compared the crash rates of 40 US states using multivariate linear regressions. The results showed that the presence or non-presence of a nighttime curfew on intermediate license holders is not a significant factor in explaining the nighttime fatal crash involvement of 16 to 19 year old drivers. To the extent that the USA and Australia can be compared, these results provide important evidence countering the assumption that curfews necessarily lead to lower relative crash rates.

There are at least two possible explanations for these results. The first is that while studies have shown curfews to be effective in reducing crash rates in some states, there are other states in which curfews are not effective, possibly because they are poorly designed. The second possible explanation is that states without nighttime curfews have managed to maintain relatively low nighttime crash rates possibly by some other specific means.

Hence, the case for introducing curfews in Australia is not clear cut. Ultimately, governments must weigh up the costs and benefits of such a policy, and take into account their perception of community support. The implication of the findings in this report is that introducing a nighttime curfew is not a guaranteed way of saving lives. There must be careful attention paid to the design of curfew policies if they are to be effective. The findings also suggest that there may be viable and equally effective alternatives to curfews.

REFERENCES

Australian Automobile Association, 2004. *SaferRoads: key results of July 2004 national survey.* http://www.aaa.asn.au

Australian Bureau of Statistics (ABS), 1982 and 2001. "Motor vehicle census." ABS Cat. No. 9309.0. Canberra.

Australian Bureau of Statistics (ABS), 2003. "Estimated resident population." ABS Cat. No. 3201.0. Canberra.

Australian Transport Safety Bureau (ATSB), 2004. "Fatal Road Crash Database." http://www.atsb.gov.au

Begg, D. and Stephenson, S., 2003. Graduated driver licensing: the New Zealand experience. *Journal of Safety Research*, 34, 99-105.

Federal Office of Road Safety (FORS), 1998. "The history of road fatalities in Australia." Monograph 23. Canberra.

Foss, R. and Goodwin, A., 2003. Enhancing the effectiveness of graduated driver licensing legislation. *Journal of Safety Research*, 34, 79-84.

Foss, R. D., Feaganes, J. R., & Rodgman, E. A., 2001. Initial effects of graduated driver licensing on 16-year-old driver crashes in North Carolina. *Journal of the American Medical Association*, 286(13), 1588– 1592.

Hartling, L., Wiebe, N., Russell, K., Petruk, J., Spinola, C. and Klassen, T. P., 2004. Graduated driver licensing for reducing motor vehicle crashes among young drivers (Cochrane Review). *The Cochrane Library,* Issue 4.

Hatcher, J. and Scarpa, J., 2001. *Background for community-level work on physical health and safety in adolescence: reviewing the literature on contributing factors*. Child Trends.

Holgate, J., 1997. *The ageing of the Australian car fleet – a discussion paper for the New Vehicle Benefits Taskforce*.

IIHS, 2004. *Licensing systems for young drivers*. http://www.hwysafety.org/safety%5Ffacts/state%5Flaws/grad%5Flicense.htm

Insurance Institute of Highway Safety (IIHS), 2004. *GDL effective dates.* Obtained through personal communications.

Lin, M. and Fearn, K., 2003. The provisional license: nighttime and passenger restrictions—a literature review. *Journal of Safety Research*, 34, 51-61.

Malloy, S., 2004. A P-plate curfew? *Green Left Weekly, Online Addition*. http://www.greenleft.org.au/back/1993/89/89p11b.htm

Mayhew, D. R., Simpson, H. M., Ferguson, S. A., and Williams, A. F., 1998. Graduated driver licensing in Nova Scotia: a survey of teenagers and parents. *Journal of Traffic Medicine*, 26(1–2), 37– 44.

McDonald, W. A., 1994. Young Driver Research Program: Literature Review on Young Drivers' Performance. Federal Office of Road Safety (FORS, now Australian Transport Safety Bureau) Contract Report 128.

Newman-Martin, A., 2004. Curfew on young drivers unfair and impractical. *Letters, Sydney Morning Herald.* August 9, 2004.

Nicholls, S., 2004. Young driver curfew: off the road by 10pm. *Sydney Morning Herald.* August 7, 2004.

Preusser, D. F., Williams, A. F., Lund, A. K., and Zador, P. L., 1990. City curfew ordinances and teenage motor vehicle injury. *Accident Analysis and Prevention*, 22(4), 391– 397.

Preusser, D. F., Williams, A. F., Zador, P. L., and Blomberg, R. D., 1984. The effect of curfew laws on motor vehicle crashes. *Law and Policy*, 6(1), 115–128.

Queensland Parliamentary Travelsafe Committee (Travelsafe). (2003). "Provisional driver and rider license restrictions." Report No. 41.

Roads and Traffic Authority (RTA), 2002. Driver and vehicle statistics.

Senserrick, T. and Whelan, M., 2003. *Graduated Driver Licensing: effectiveness of systems and individual components.* Monash University Accident Research Centre Report No. 209.

Shope, J. T., Molnar, L. J., Elliott, M. R., and Waller, P. F., 2001. Graduated driver licensing in Michigan—early impact on motor vehicle crashes among 16-year-old drivers. *Journal of the American Medical Association*, 286(13), 1593– 1598.

Street, L. S., 2004. Modern Dilemma: should a night-time curfew be imposed on all young drivers? *The Weekend Australian Magazine*, October 9-10.

Ulmer, R. G., Preusser, D. F., Williams, A. F., Ferguson, S. A. and Farmer, C., F. 2000. Effect of Florida's graduated licensing program on the crash rate of teenage drivers. *Accident Analysis and Prevention*, 34(4), 527-532.

United States General Accounting Office (GAO), 2003. Highway safety: research continues on a variety of factors that contribute to motor vehicle crashes. *Report to Congressional Requesters.*

Williams, A. F., 1985. Nighttime driving and fatal crash involvement of teenagers. *Accident Analysis and Prevention*, 17 (1), 1-5.

Williams, A. F., Nelson, L. A., & Leaf, W. A., 2002. Responses of teenagers and their parents to California's graduated licensing system. *Accident Analysis and Prevention*, 34, 835–842.

Williams, A., F., 2000. *North America's Approach to the Young Driver Problem.* Presented at the Novice Drivers Conference Bristol, England, June 1-2, 2000. Insurance Institute for Highway Safety.

Williams, A., F., 2003. *Statement before the Transportation Committee, State of Hawaii House of Representatives.* Insurance Institute for Highway Safety.

Figure 1 Fatal crash rates per population by driver age and gender, Australia, 2002 (ATSB, 2004; ABS, 2003)

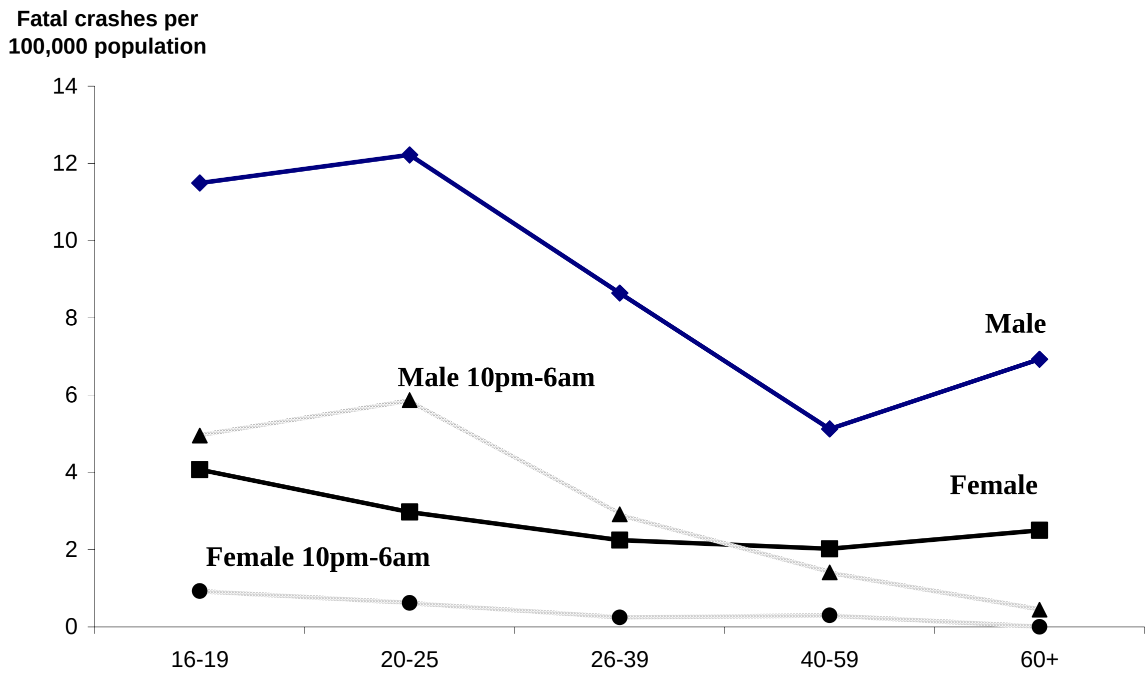


Figure 2 Fatal crash rates per licensed drivers by driver age and gender, and total fatal crashes, New South Wales, 2001 (RTA, 2002; ATSB, 2004)

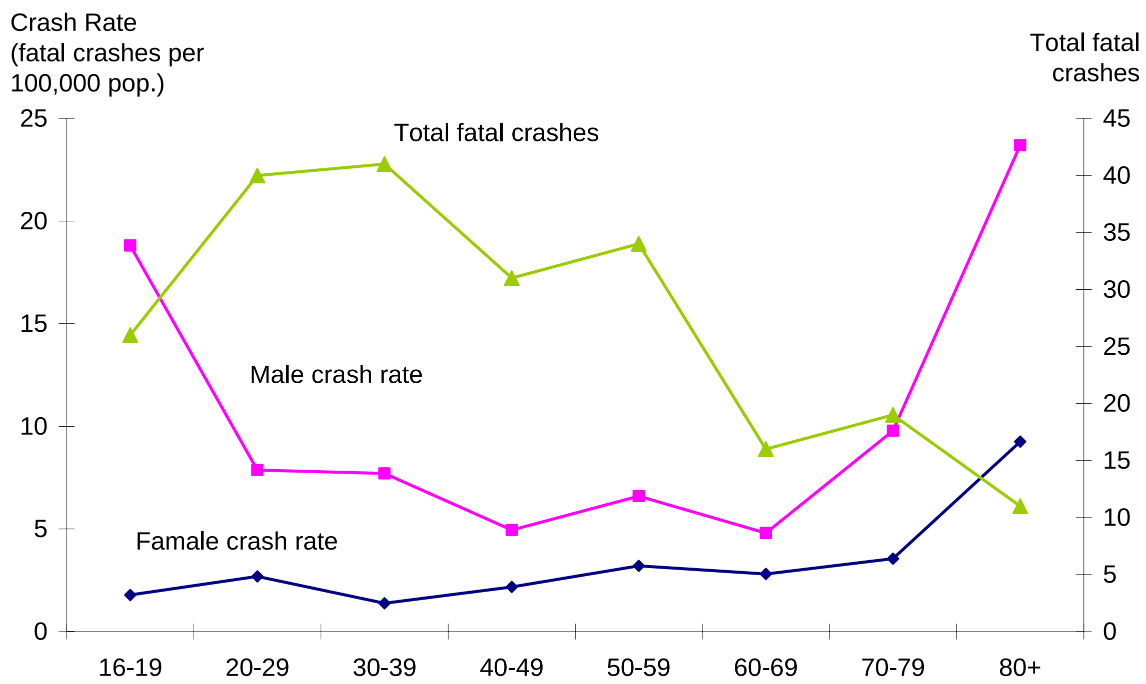


Table 1 Number of states with a nighttime curfew by year

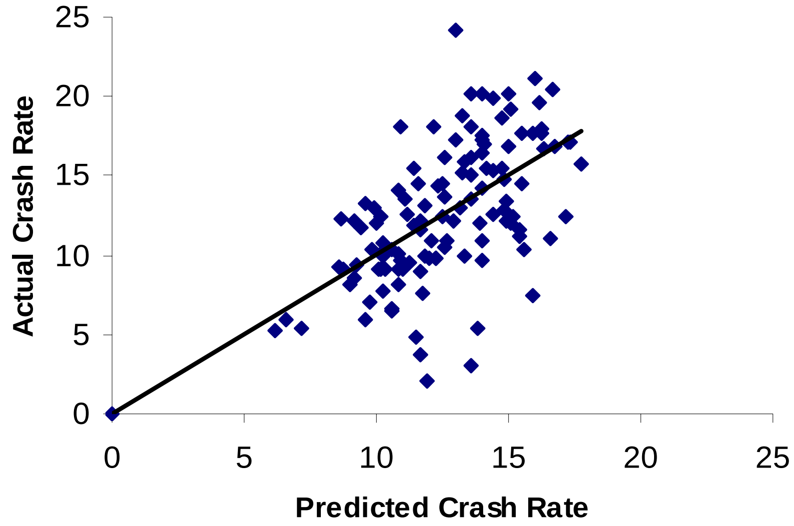
Year	Number of states
1999	16
2000	17
2001	21

Table 2 Results of regression analyses

	Young drivers		Young male drivers		Young female drivers	
Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Constant	21.585	2.721	31.032	-3.256	12.565	2.829
	(1.653)	(1.264)	(1.453)	-(.831)	(1.262)	(1.915)
Nighttime curfew	0.322	-0.711	1.237	-1.345	-0.351	-0.213
	(.249)	-(.987)	(.573)	-(1.099)	-(.352)	-(.389)
Licensure rate	7.261 *	8.694 **	19.029 **	22.321 **	-1.338	1.388
	(2.095)	(3.095)	(3.832)	(4.919)	-(.577)	0.743
Reference crash rate	0.572 *	0.784 **	0.966	1.402	0.265	0.388
	(2.305)	(4.582)	(2.279) *	(4.606) **	(1.393)	2.954
Ratio of young male to female licensed drivers	-9.749		-14.819		-7.982	
	-(1.021)		-(.95)		-(1.061)	
Transition year	-0.824		-2.232		0.797	
	-(.629)		-(1.018)		(.761)	
1999	-0.503		-1.350		0.011	
	-(.548)		-(.886)		(.015)	
2000	0.846		0.969		0.391	
	(.984)		(.679)		(.586)	
Income	0.000		0.000		0.000	
	-(1.621)		-(1.567)		-(.513)	
Distance travelled	-20.898		-287.469		224.808	
	-(.079)		-(.65)		(1.099)	
Urban / Rural distance travelled (ln)	1.143		2.238	1.634	0.325	
	(1.604)		(1.93)	(1.82)	(.577)	
Restrictions end between 17 and 19	-1.371		-3.127		0.141	
	-(1.074)		-(1.467)		(.143)	
Minimum licensure age <16	1.792		1.450		1.697	
	(1.578)		(.766)		(1.943)	
Number of observations	120	120	120	120	120	120
F	4.300 **	13.140 **	4.946 **	12.584 **	1.695	3.647*
R-squared	0.325	0.254	0.357	0.304	0.160	0.086
Adj R-squared	0.250	0.234	0.285	0.280	0.065	0.063

*Note: ** p<0.01, *p<0.05; figures in brackets are t-statistics.*

Figure 3 Plot of actual crash rates against predicted crash rates (Model 1).



APPENDIX 1 – STATES IN REGRESSION ANALYSES

State	16-19 y.o. Driver Crash Rate (Fatal crashes per 100,000 pop)	16-19 y.o. Male Driver Crash Rate (Fatal crashes per 100,000 pop)	16-19 y.o. Female Driver Crash Rate (Fatal crashes per 100,000 pop)	Nighttime Curfew (1=yes, 0=no)	16-19 y.o.Licensure Rate (licensed drivers per 100,000 pop)	25-54 y.o. Driver Crash Rate (Fatal crashes per 100,000 pop)	16-19 Male Licensed drivers / 16-19 Female Licensed Drivers	Transition Year (1=yes, 0=no)	Per Capita Income ($US / person)	Distance Travelled per Person (Total Vehicle Miles Travelled / 100,000 pop)	Ratio of Urban / Rural Distance Travelled (Natural Log)	Restrictions End Before 19 (1=yes, 0=no)	Minimum Intermediate Licensure Less Than 16 (1=yes, 0=no)
1999													
Alabama	17.92	25.33	10.15	0	0.82	8.92	1.08	0	22722	0.012	-0.05	0	0
Alaska	18.13	27.84	5.86	0	0.63	4.94	1.14	0	28100	0.008	-0.09	0	0
Arizona	12.18	20.03	5.35	0	0.54	6.67	1.13	0	24057	0.010	0.59	0	0
Arkansas	11.18	17.44	4.00	0	0.68	9.63	1.07	0	21137	0.011	-0.61	0	0
Connecticut	8.09	12.00	1.65	0	0.60	2.67	1.08	0	38332	0.009	1.11	0	0
Florida	15.41	21.82	8.36	1	0.74	7.96	1.04	0	26894	0.010	1.03	1	0
Georgia	10.91	13.84	7.91	1	0.62	6.31	1.05	0	26359	0.013	0.27	1	0
Hawaii	3.77	3.52	4.07	0	0.68	4.14	1.18	0	26973	0.007	0.85	0	0
Idaho	16.89	23.85	8.16	0	0.84	6.44	1.02	0	22786	0.011	-0.59	0	1
Illinois	9.99	15.08	4.50	1	0.47	5.07	1.04	0	30212	0.008	0.82	1	0
Iowa	11.65	12.63	10.34	1	0.75	5.74	1.00	1	25118	0.010	-0.59	1	0
Kansas	19.63	29.97	9.26	0	0.85	6.33	1.06	0	26195	0.010	-0.11	0	1
Kentucky	16.09	21.70	9.22	0	0.61	7.03	1.06	0	22763	0.013	-0.30	0	0
Louisiana	13.48	20.39	4.93	1	0.47	10.11	1.06	0	22014	0.009	-0.20	1	0
Maine	7.74	14.81	2.66	0	0.69	4.11	1.02	0	24484	0.012	-1.04	1	0
Maryland	13.03	18.27	7.23	1	0.52	4.44	1.02	0	31796	0.010	0.78	1	0
Massachusetts	9.30	13.56	4.43	1	0.60	2.84	1.09	1	34227	0.008	1.60	1	0
Michigan	9.67	14.39	4.14	1	0.60	5.22	1.08	0	28095	0.010	0.46	1	0
Minnesota	9.11	14.38	5.74	0	0.56	3.51	1.04	0	30106	0.010	0.05	0	0
Missouri	20.21	31.81	8.12	0	0.74	6.92	1.10	0	25697	0.012	0.19	0	0
Montana	20.15	25.13	15.29	0	0.72	7.38	1.07	0	21585	0.011	-1.23	0	0
Nebraska	16.12	22.52	5.39	1	0.93	6.66	1.07	1	26465	0.011	-0.50	1	0
Nevada	5.36	7.50	2.21	0	0.57	6.04	1.09	0	29184	0.010	0.60	0	1
New Hamp.	10.03	19.08	2.98	1	0.88	3.37	1.03	0	30380	0.010	-0.36	1	0
New Jersey	7.01	9.87	3.83	0	0.51	3.16	1.06	0	35215	0.008	1.41	0	0
New Mexico	17.11	26.00	7.23	0	0.55	11.24	1.07	0	21042	0.013	-0.53	0	1
New York	5.19	8.56	2.04	1	0.36	3.11	1.21	0	32816	0.007	0.90	1	0
North Carolina	9.96	15.19	5.22	1	0.59	6.71	1.05	0	25560	0.012	0.02	0	0
North Dakota	9.74	18.71	0.00	0	0.84	6.83	1.07	0	23180	0.011	-1.09	0	0
Ohio	13.58	18.22	8.25	1	0.66	5.04	1.04	1	26859	0.009	0.43	1	0
Pennsylvania	11.98	18.24	5.81	1	0.59	5.32	1.14	0	27937	0.009	0.21	1	0
Rhode Island	2.04	3.51	0.00	1	0.58	5.12	1.05	1	27459	0.009	1.87	1	0
South Dakota	15.51	22.13	10.35	0	0.82	4.46	1.04	0	24475	0.011	-1.23	0	1
Tennessee	17.74	27.90	7.75	0	0.82	8.67	1.04	0	24898	0.012	0.18	0	0
Texas	13.02	19.75	6.36	0	0.58	6.56	1.09	0	26250	0.010	0.69	0	0
Vermont	8.11	15.38	0.00	0	0.67	3.44	1.05	0	25881	0.012	-0.69	0	0
Virginia	14.47	25.78	4.61	1	0.73	4.06	0.99	0	29226	0.011	0.31	1	0
Washington	9.11	14.97	4.29	0	0.66	3.86	1.06	0	30037	0.009	0.75	1	0
West Virginia	18.84	31.10	6.79	0	0.60	7.65	1.09	0	20729	0.011	-0.96	0	0
Wyoming	17.23	24.30	9.98	0	0.70	9.77	1.05	0	26536	0.016	-1.04	0	0

	16-19 y.o. Driver Crash Rate	16-19 y.o. Male Driver Crash Rate	16-19 y.o. Female Driver Crash Rate	Nighttime Curfew	16-19 y.o.Licensure Rate	25-54 y.o. Driver Crash Rate	16-19 Male Licensed drivers / 16-19 Female Licensed Drivers	Transition Year	Per Capita Income	Distance Travelled per Person	Ratio of Urban / Rural Distance Travelled	Restrictions End Before 19	Minimum Intermediate Licensure Less Than 16
State	(Fatal crashes per 100,000 pop)	(Fatal crashes per 100,000 pop)	(Fatal crashes per 100,000 pop)	(1=yes, 0=no)	(licensed drivers per 100,000 pop)	(Fatal crashes per 100,000 pop)		(1=yes, 0=no)	($US / person)	(Total Vehicle Miles Travelled / 100,000 pop)	(Natural Log)	(1=yes, 0=no)	(1=yes, 0=no)
2000													
Alabama	12.49	23.17	2.96	0	0.83	8.03	1.06	0	23768	0.012	-0.04	0	0
Alaska	24.15	39.15	9.53	0	0.61	7.11	1.13	0	29863	0.008	-0.06	0	0
Arizona	15.31	23.33	7.94	0	0.63	6.40	1.12	0	25661	0.010	0.58	0	0
Arkansas	10.36	14.35	5.25	0	0.62	8.53	1.06	0	21926	0.011	-0.59	0	0
Connecticut	10.84	13.87	4.85	0	0.50	4.71	1.06	0	41495	0.009	1.10	0	0
Florida	16.69	25.32	8.42	1	0.78	8.18	1.03	0	28511	0.010	1.10	1	0
Georgia	15.21	20.50	8.80	1	0.69	6.32	1.07	0	27989	0.014	0.19	1	0
Hawaii	14.25	20.78	7.98	0	0.78	4.90	1.17	0	28417	0.007	0.91	0	0
Idaho	15.76	22.43	9.44	0	0.85	5.56	0.98	0	24076	0.010	-0.54	0	1
Illinois	9.80	14.95	4.28	1	0.65	4.69	1.03	0	32187	0.009	0.83	1	0
Iowa	12.62	23.06	1.53	1	0.97	4.36	1.00	0	26554	0.010	-0.57	1	0
Kansas	20.48	31.50	9.20	0	0.82	5.60	1.04	0	27694	0.011	-0.11	0	1
Kentucky	16.94	27.00	7.56	0	0.58	6.58	1.05	0	24414	0.012	-0.29	0	0
Louisiana	11.98	19.06	5.38	1	0.46	10.88	1.06	0	23080	0.009	-0.17	1	0
Maine	12.45	14.70	10.80	0	0.68	2.10	1.01	0	25972	0.011	-1.04	1	0
Maryland	14.09	18.26	8.00	1	0.53	4.51	1.02	0	34257	0.010	0.75	1	0
Massachusetts	9.44	13.22	6.01	1	0.51	2.71	1.09	0	37756	0.009	1.61	1	0
Michigan	7.63	11.80	3.41	1	0.53	6.00	1.09	0	29553	0.010	0.47	1	0
Minnesota	8.91	13.73	4.00	0	0.57	4.42	1.04	0	32018	0.010	0.07	0	0
Missouri	19.85	31.80	9.42	0	0.64	7.27	1.09	0	27243	0.012	0.12	0	0
Montana	13.42	18.64	8.12	0	0.63	8.96	1.07	0	22932	0.011	-1.20	0	0
Nebraska	12.45	19.93	1.99	1	0.74	5.39	1.07	0	27627	0.011	-0.49	1	0
Nevada	12.14	18.72	2.33	0	0.60	5.47	1.08	0	30438	0.009	0.70	0	1
New Hamp.	4.89	9.27	0.00	1	0.83	3.92	1.04	0	33398	0.009	-0.36	1	0
New Jersey	9.07	14.01	4.33	0	0.57	3.21	1.07	0	38372	0.008	1.38	0	0
New Mexico	14.46	19.39	10.16	1	0.72	6.95	1.04	1	22134	0.012	-0.57	1	1
New York	5.36	8.33	2.21	1	0.41	2.67	1.21	0	34900	0.007	0.92	1	0
North Carolina	17.56	24.32	11.10	1	0.58	6.51	1.07	0	27071	0.012	0.03	0	0
North Dakota	20.22	37.25	4.34	0	0.76	7.77	1.06	0	25109	0.012	-1.07	0	0
Ohio	9.77	16.99	3.20	1	0.56	5.06	1.03	0	28208	0.009	0.42	1	0
Pennsylvania	10.34	15.54	4.03	1	0.55	5.22	1.14	1	29697	0.009	0.21	1	0
Rhode Island	18.12	29.79	8.33	1	0.59	2.46	1.06	0	29216	0.009	1.87	1	0
South Dakota	11.02	19.48	4.03	0	0.91	5.74	1.04	0	25722	0.012	-1.23	0	1
Tennessee	17.17	21.76	11.51	0	0.78	8.98	1.03	0	26099	0.012	0.15	0	0
Texas	14.82	24.08	5.70	0	0.60	7.61	1.08	0	28313	0.011	0.68	0	0
Vermont	13.73	14.35	12.90	0	0.69	5.20	1.06	0	27680	0.011	-0.91	0	0
Virginia	17.24	27.51	6.91	1	0.76	4.71	1.00	0	31084	0.011	0.28	1	0
Washington	9.80	14.34	5.23	0	0.74	4.01	1.06	0	31780	0.010	0.74	1	0
West Virginia	11.66	18.70	3.58	0	0.59	8.71	1.03	0	21901	0.011	-0.97	0	0
Wyoming	15.87	31.38	0.00	0	0.77	6.00	1.05	0	28463	0.017	-0.96	0	0

State	16-19 y.o. Driver Crash Rate (Fatal crashes per 100,000 pop)	16-19 y.o. Male Driver Crash Rate (Fatal crashes per 100,000 pop)	16-19 y.o. Female Driver Crash Rate (Fatal crashes per 100,000 pop)	Nighttime Curfew (1=yes, 0=no)	16-19 y.o.Licensure Rate (licensed drivers per 100,000 pop)	25-54 y.o. Driver Crash Rate (Fatal crashes per 100,000 pop)	16-19 Male Licensed drivers / 16-19 Female Licensed Drivers	Transition Year (1=yes, 0=no)	Per Capita Income ($US / person)	Distance Travelled per Person (Total Vehicle Miles Travelled / 100,000 pop)	Ratio of Urban / Rural Distance Travelled (Natural Log)	Restrictions End Before 19 (1=yes, 0=no)	Minimum Intermediate Licensure Less Than 16 (1=yes, 0=no)
						2001							
Alabama	12.44	19.15	5.38	0	0.70	8.15	1.05	0	24845	0.013	-0.06	0	0
Alaska	10.23	14.08	4.88	0	0.53	5.44	1.12	0	31837	0.008	-0.08	0	0
Arizona	12.00	17.85	5.81	0	0.51	8.47	1.11	0	26055	0.010	0.58	0	0
Arkansas	10.97	17.97	3.89	0	0.69	6.77	1.06	0	23072	0.011	-0.59	0	0
Connecticut	12.28	14.35	8.95	0	0.47	4.19	1.06	0	42550	0.010	1.10	0	0
Florida	15.09	26.07	5.43	1	0.58	8.03	1.06	0	29247	0.010	1.10	1	0
Georgia	14.51	22.87	6.68	1	0.75	5.70	1.05	0	28555	0.014	0.16	1	0
Hawaii	14.36	29.56	0.00	0	0.60	5.42	1.15	0	28690	0.007	0.91	0	0
Idaho	17.65	22.21	10.07	1	0.83	4.58	0.98	1	24947	0.011	-0.53	0	1
Illinois	12.18	20.26	6.04	1	0.71	4.39	1.03	0	32782	0.009	0.85	1	0
Iowa	10.46	19.23	3.34	1	0.80	5.15	1.00	0	27357	0.010	-0.56	1	0
Kansas	19.20	33.42	7.25	0	0.66	6.64	1.05	0	28490	0.011	-0.10	0	1
Kentucky	12.51	20.37	5.51	0	0.41	5.41	1.06	0	24954	0.012	-0.31	0	0
Louisiana	16.81	23.64	9.01	1	0.63	10.45	1.05	0	24517	0.010	-0.16	1	0
Maine	13.30	17.56	8.49	0	0.59	4.20	1.01	0	27157	0.011	-1.03	1	0
Maryland	12.17	17.71	7.04	1	0.45	4.49	1.03	0	35355	0.010	0.74	1	0
Massachusetts	9.17	13.16	4.14	1	0.56	3.06	1.08	0	38945	0.009	1.58	1	0
Michigan	9.10	11.22	6.51	1	0.61	4.92	1.09	0	29499	0.010	0.49	1	0
Minnesota	6.65	9.95	2.40	0	0.63	3.30	1.03	0	32722	0.011	0.06	0	0
Missouri	15.42	19.55	9.92	1	0.61	7.32	1.08	1	27932	0.012	0.13	1	0
Montana	7.40	9.99	4.16	0	0.85	9.68	1.06	0	24036	0.011	-1.22	0	0
Nebraska	11.89	19.95	4.55	1	0.83	3.93	1.05	0	28713	0.011	-0.48	1	0
Nevada	12.89	18.10	8.83	0	0.65	5.91	1.08	0	30347	0.009	0.72	0	1
New Hamp.	5.97	5.47	6.56	1	0.75	3.61	1.05	0	33771	0.010	-0.36	1	0
New Jersey	8.53	14.11	2.59	1	0.52	3.17	1.04	1	39077	0.008	1.36	0	0
New Mexico	17.73	26.23	8.71	1	0.61	9.76	1.04	0	23928	0.013	-0.58	1	1
New York	5.96	9.02	2.68	1	0.42	3.07	1.20	0	35626	0.007	0.91	1	0
North Carolina	10.86	15.42	5.49	1	0.54	6.40	1.07	0	27501	0.012	0.02	0	0
North Dakota	16.41	31.82	0.00	0	0.78	7.50	1.05	0	25830	0.012	-1.06	0	0
Ohio	9.98	13.39	6.29	1	0.59	5.49	1.03	0	28627	0.009	0.43	1	0
Pennsylvania	11.67	18.19	4.97	1	0.50	5.43	1.14	0	30318	0.009	0.22	1	0
Rhode Island	13.19	24.69	3.47	1	0.47	4.59	1.03	0	30103	0.008	1.90	1	0
South Dakota	21.20	33.90	9.17	0	0.95	6.29	1.05	0	26876	0.012	-1.22	0	1
Tennessee	18.69	34.13	8.61	0	0.69	7.65	1.03	0	26916	0.012	0.12	0	0
Texas	18.09	26.70	8.32	0	0.56	7.44	1.06	0	28943	0.011	0.61	0	0
Vermont	6.55	6.82	6.30	0	0.79	2.91	1.06	0	28988	0.016	-1.12	0	0
Virginia	9.15	12.59	4.71	1	0.55	4.34	1.00	0	32328	0.010	0.24	1	0
Washington	10.41	15.94	4.46	0	0.73	3.34	1.05	0	32271	0.009	0.75	1	0
West Virginia	9.51	13.25	4.46	1	0.61	6.13	1.02	1	23068	0.011	-0.99	1	0
Wyoming	3.01	0.00	6.53	0	0.62	10.89	1.07	0	30197	0.017	-1.06	0	0