An economic evaluation of the mandatory bicycle helmet legislation in Western Australia

Delia Hendrie, Matthew Legge, Diana Rosman and Carol Kirov
Road Accident Prevention Research Unit
Department of Public Health
The University of Western Australia
Nedlands WA 6907

Introduction

In Australia, the mandatory helmet wearing legislation for bicyclists was first introduced in Victoria in July 1990, and other states and territories introduced compulsory helmet wearing in 1991 and 1992. In Western Australia the helmet wearing legislation was invoked in January 1992, but was only made effective from July 1992. A six-month phasing in period was then applied during which infringement notices issued for not wearing a bicycle helmet were cancelled if the recipient provided proof of purchase of a helmet within 14 days.

The intention of the bicycle helmet legislation was to increase helmet wearing rates and thus reduce the risk of head injury to bicyclists involved in road crashes. Four epidemiological studies – two in Australia and one in each of the United States and the United Kingdom – found that the wearing of bicycle helmets had resulted in reductions in the risk of head injury of between 45% and 85% (Thompson, Rivara & Thompson, 1989; McDermott, Lane, Brazenor & Debney, 1993; Maimaris, Sommers, Browning & Palmer, 1994; Thomas, Acton, Nixen, Battistutta, Pitt & Clark, 1994).

Since the introduction of the mandatory helmet wearing legislation, four Australian states have examined its effectiveness in reducing head injury to bicyclists. In Victoria, evaluations of the helmet wearing law were made in each of the first four years following its introduction. Using regression analysis, the studies in the first two post-law years found a statistically significant reduction in the number and proportion of head injuries among hospitalised bicyclists (Cameron, Heiman & Neiger, 1992; Finch, Newstead, Cameron & Vulcan, 1993). The evaluation of the first three years of helmet legislation reported conflicting data from the logistic regression analysis modelling the proportion of severely injured crash-involved bicyclists with a head injury. For bicyclists injured in crashes not involving a motor vehicle, head injury rates were significantly lower than the pre-law level in each of the three post-law years. For bicyclists injured in crashes involving a motor vehicle, no additional benefit of the law over pre-law trends in reducing head injury rates was found in the three post-law years using hospital admissions data, while an analysis of insurance claims data showed bicyclist head injury rates significantly below pre-law trend predictions in the second post-law year only (Newstead, Cameron, Gantzer & Finch, 1994). The final Victorian study, analysing the effects of the first four years of the helmet wearing legislation, undertook some preliminary analyses of the hospital admissions data, which suggested the apparent increase in bicyclist admissions to hospital in the third and fourth years after the legislation was most likely the result of changes in the funding arrangements for publicly funded hospitals. After correcting the hospital admissions data downwards for these years downwards to remove this effect, a multivariate time series analysis of the number of head-injured bicyclists indicated that there had been a statistically significant reduction of 40% in the number of head-injured bicyclists admitted to hospital across Victoria compared with pre-law trends (Carr, Skalova & Cameron, 1995).

In other states, the evaluations of the compulsory helmet wearing legislation were less sophisticated in a statistical sense. In South Australia, Marshall and White (1994) conducted an analysis of hospital admissions in South Australia in the year immediately before the legislation compared with the year immediately after and for the two years before and two years after. After accounting for exposure and changing hospital admission practices with respect to concussion, they found that the use of bicycle helmets was linked to 12% and 25% decreases in hospital admissions for cycling injuries which were potentially preventable by the use of a bicycle helmet. In New South Wales and Queensland, an analysis of hospital data showed that head injuries to bicyclists had decreased relatively more than other injuries sustained over the period when compulsory helmet wearing was introduced (Williams, 1995; King & Fraine, 1994).

Robinson (1996a) and Robinson (1996b) have challenged the results of the evaluations of the effectiveness of the bicycle helmet legislation in reducing the number of bicyclists with head injury. Robinson (1996a) re-examined the injury data for Victoria and showed that the percentage of bicyclists and pedestrians suffering head injuries when hit by motor vehicles followed similar, reducing trends. She suggested that these trends may have been caused by the major road safety initiatives directed at speeding and drink-driving, which were introduced at the same time as the helmet wearing law, and argued that the reduction in cycling following the introduction of compulsory helmet wearing may have generated a net loss of health benefits as a result of the helmet law. After examining injury data for different states, Robinson (1996b) questioned the results of the studies claiming head injury reductions following the introduction of the helmet wearing legislation. He discussed various shortcomings in the evaluations, in particular noting the similar, longer term trend in the reduction of the proportion of head injuries for pedestrians and bicyclists in Western Australia and the difficulties in attributing changes in injury rates over time to any one particular factor when so many other factors were also changing.

The purpose of this present study was to conduct an economic evaluation of the mandatory helmet wearing legislation in Western Australia. The study had two main objectives. First, the effectiveness of the helmet wearing law in reducing head injuries to cyclists in Western Australia was evaluated, taking into account trends in head injuries to pedestrians (who were used as a control group for bicyclists). Second, the cost-effectiveness of the bicycle helmet legislation was examined in terms of its costs and outcomes. The only outcome included in the cost-effectiveness analysis was the change in the number of head injuries to bicyclists. Other possible outcomes, such as the impact of the legislation on cycling activity and associated changes in physical fitness and related health conditions, were not included in the analysis.

Method

The study consisted of three parts: (i) the analysis of the effectiveness of the bicycle helmet legislation in reducing the number of head injuries to bicyclists, (ii) the examination of the cost to the community of the helmet wearing legislation, and (iii) the calculation of the cost-effectiveness of the mandatory helmet wearing legislation based on the findings of parts (i) and (ii).

The economic evaluation was conducted over the period from the start of the legislation in 1992 until 1998, which is the last year for which hospital data on the number of head injuries is currently available. Costs relating to the helmet wearing legislation that were incurred prior to 1992 were included as a cost of this law. A societal perspective was adopted, which means that within the scope of the study the analysis included all costs (no matter who pays them) and all benefits (no matter who receives them). Costs were expressed in 1998 Australian dollars.

Effectiveness of the Bicycle Helmet Legislation

Data Sources

Injury data was obtained from the Western Australian Road Injury Database, which is a database consisting of linked records of police crash reports and hospital admission records of road crash casualties. The study used only the hospital component of the Road Injury Database. Injury data for less severe levels of injury (i.e. casualty attendances and GP consultations) was not available so these injuries could not be included in the evaluation. Bicyclist fatalities who died before being admitted to hospital were also not included since the numbers in a single year were too low to conduct statistical analyses.

Road user type was identified in the Road Injury Database using the codes for external causes of injury of the *International classification of diseases* (ICD9-CM). Bicyclists were defined as comprising the following codes: 810.6 to 825.6 and 826.1 to 829.1. Pedestrians, who were used as a control group, were defined as 810.7 to 825.7 and 826.0 to 829.0.

Using the diagnosis fields in the hospital data, each record was classified as involving either a head injury or no head injury as follows:

- 1988 to 1998: For this period, diagnoses in the hospital records were classified using the ICD9-CM version of the *International classification of diseases*. A computerised conversion table was used to convert injuries coded by ICD9-CM into body regions and injury severity levels of the Abbreviated Injury Scale (AIS). All injuries coded to the AIS body region of head were counted as a head injury.
- 1979 to 1987: For this period, diagnoses in the hospital records were coded according to the ICD-9 version of the *International classification of diseases*. The computerised conversion table only maps from the ICD9-CM version to the AIS, so head injuries were coded directly from the ICD-9 as falling in the ranges of 800-804, 850-854, 873.0-873.1, 900 and 950-951.
- 1971 to 1978: For this period, diagnoses were coded according to the ICD-8 version of the *International classification of diseases*. Head injuries were coded as the following ranges: 800-804, 850-854, 873, 904 and 950-951.

If one or more head injury diagnoses were found in a hospital record, then the record was classified as having a head injury. All other records were classified as not having a head injury. Two other variables from the hospital records – gender and age of the casualty - were also used in the analysis.

Two indicator variables were used to represent the pre- and post-law period when the promotion of the wearing of bicycle helmets started and the pre- and post-law period of the bicycle helmet legislation. Promotion of helmet wearing in Western Australia did not commence formally on any particular date. While some minor promotional activities took place in 1984 and 1985, the establishment of Bikewest in 1986 was assumed to be the date that signified the start of the main campaign to promote helmet wearing in Western Australia. Bikewest ran a helmet rebate scheme from December 1987 to February 1994, and a helmet subsidy scheme was operated through schools between 1988 and 1990.

The indicator variables had two values only: one when the effect was operational and zero otherwise.

Statistical Methods
Two approaches were used to test the effectiveness of the bicycle helmet legislation in reducing head injuries.

The first method used aggregated data for each year from 1976 to 1998. Least squares regression was used to model the ratio of the proportion of bicyclists with head injury to the proportion of pedestrians with head injury. This variable, with the proportion of pedestrians with head injury in the denominator, was used in order to control for the decreasing trend in the proportion of all road users (including bicyclists and pedestrians) with head injury (see Figure 2.1). Possible explanations of this decreasing trend include changes in road safety affecting all road user groups, changes in hospital admission procedures, and changes in diagnostic coding procedures. The proportion of bicyclists and pedestrians with head injury was used in the numerator and denominator of the ratio respectively, rather than the number with head injury, to control for changes in levels of exposure for bicyclists and pedestrians. This method of dealing with exposure was used since relevant information on bicycle use or pedestrian activity was not available.

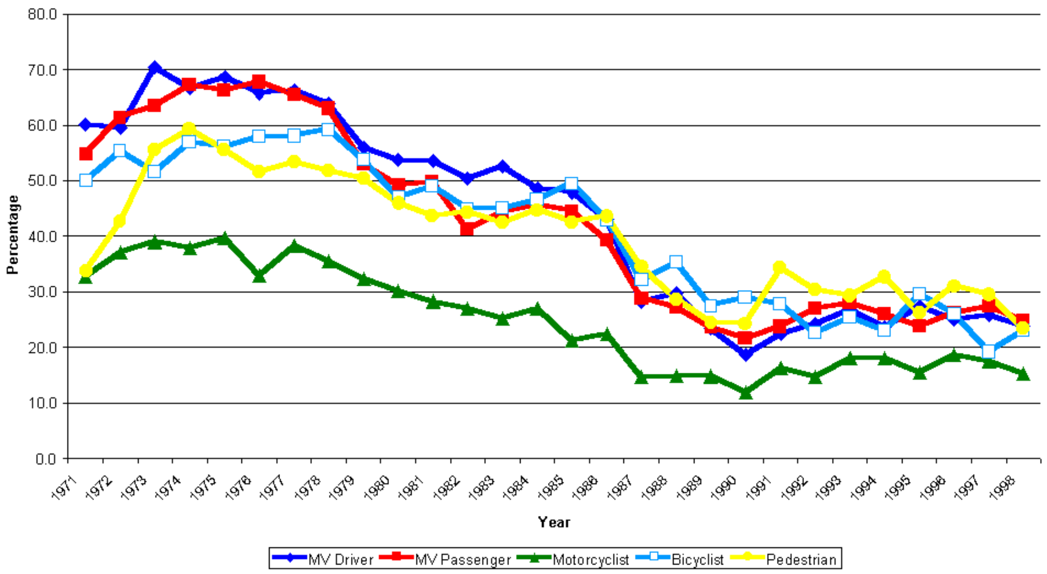

Figure .1 Percentage of Road Users with Head Injury, Western Australia, 1971 to 1998

The explanatory variables tested in this aggregated data model were time, time-squared, time-cubed and the two indicator variables representing the start of the promotion of helmet wearing in 1986 and the introduction of the helmet wearing legislation in 1992.

The model was fitted using the SAS procedure REG (SAS Institute, 1990). The forward and backward stepwise options were used whereby explanatory variables are introduced or removed from the model using a set of criteria based on the variable's p-value. To be considered in the model, the variable had to have a p-value of 0.3 or less, and a p-value of less than 0.1 was required for the variable to be kept in the model.

The second approach to testing the effectiveness of the helmet wearing law in reducing head injuries to bicyclists used pooled individual data for bicyclists and pedestrians for 1976 to 1998. As in the aggregated data model, pedestrians were included in the data set to control for the decreasing trend in the number of all road users with head injury. Logistic regression was used to model the likelihood of an individual in the data set having a head injury. The explanatory variables included in the model were time, time-squared, the casualty's age and gender, the indicator variables for the start of helmet promotion and the introduction of the helmet wearing legislation, and a road user indicator variable that differentiated between bicyclists and pedestrians. Two interaction terms were also included: (i) the interaction between the road user indicator (i.e. bicyclist or pedestrian) and the start of the helmet promotion campaign, and (ii) the interaction between the road user indicator and the introduction of the legislation. These interaction variables took on a non-zero value (i.e. one) when the person was a bicyclist hospitalised after the start of the helmet promotion campaign or after the introduction of the helmet wearing law. The interactions were designed in this way to determine if either promoting helmet wearing or the helmet wearing legislation had an effect on bicyclists over and above any factors affecting pedestrians. The model was fitted using the SAS procedure LOGISTIC (SAS Institute, 1990).

Costs of the Bicycle Helmet Legislation

Costing framework

The following costs of the helmet wearing legislation were included in the economic evaluation:

- public education campaigns,
- enforcement,
- the purchase of helmets, and
- the administration of the helmet rebate scheme.

The reason for only including the administration cost of the helmet rebate scheme, rather than the total cost, was that rebates were in effect transfer payments from taxpayers to bicyclists. Using a societal perspective, transfer payments are not regarded as a real cost in economic evaluation studies (Drummond, O'Brien, Stoddart and Torrance, 1997).

The following costs of the helmet wearing law were not included in the economic evaluation:

- introduction of the legislation,
- the administration of the helmet subsidy scheme,
- time spent buying helmets, putting them on and taking them off,
- reduced cycling activity, and
- intangible costs.

The costs associated with the introduction of the bicycle helmet legislation included the establishment of a working committee in 1990 to make recommendations relating to helmet wearing to the Minister of Police, the time spent in promoting and drafting the helmet wearing legislation, and the parliamentary time spent debating and passing the legislation. These costs (excluding the working committee) were calculated as approximately $100 000 (1998 dollars), which could be amortised over the life of the legislation to provide annual equivalent costs. Since the magnitude of the annual equivalent cost would be relatively small and unlikely to make any difference to the study result, this cost component was excluded from the analysis.

The helmet subsidy scheme was operated through Parent and Citizen associations at Western Australian schools. Subsidies are also transfer payments, thus only the administration cost should have been included as a cost of the helmet wearing legislation. However, no information was available to use as the basis to calculate this cost.

Bicyclists spent time buying helmets and putting them on and taking them off. There was an opportunity cost associated with this time, which could have been calculated on the basis of the average time taken to perform these activities. The inclusion of this type of lost time factor in economic evaluation studies is controversial, however, and for this reason this cost was excluded from the analysis (Drummond, O'Brien, Stoddard and Torrance, 1997).

The enforced wearing of bicycle helmets may have resulted in reduced cycling activity, which could have resulted in the loss of health benefits from a decrease in physical activity and negative environmental effects due to the increased use of motor vehicles. The former outcome would have occurred if people who cycled less because of the helmet wearing law did not substitute other physical activity for cycling. The latter outcome would have resulted if people who had cycled as a means of transport changed to using private transport. The magnitude of these costs are potentially considerable, but were outside the scope of this study.

The final cost item omitted from this study was intangible costs such as the loss of freedom of choice to wear a helmet. Loss of freedom of choice would have led to a welfare loss for those individuals who were forced to adopt levels of precautionary behaviour in excess of their perceived risk (Van Osch, 1993). Public health policy such as the helmet wearing legislation gives priority to social health and safety requirements or the 'common good' rather than to individual self-interest. This is a complex area for which cost calculations would have been extremely difficult.

Data Sources

Mass media campaigns promoting helmet wearing were conducted between December 1987 and March 1988, in June and July 1988, and again in December 1988. Bikewest provided estimates of the cost of these campaigns from its financial records. From 1991, media campaigns and other promotional material encouraging helmet wearing were funded through the Road Trauma Trust Fund. The cost of these campaigns were obtained from the financial records of the Road Trauma Trust Fund.

Helmet wearing is enforced by the Bicycle Safety Section of the Western Australian Police Service and by other police officers on duty who can apprehend bicyclists not wearing a helmet. Only the cost of the enforcement carried out by the Bicycle Safety Section was included in this study. Approximately 40% of the offences of the Bicycle Safety Section during the post-law period were for failing to wear, or correctly wear, a bicycle helmet. This proportion of the salary cost of the Bicycle Safety Section was allocated as the cost of police resources used to enforce the helmet wearing legislation.

Several assumptions had to be used to apportion a cost of helmet purchases to the bicycle helmet legislation. The observational surveys conducted by the Police, and in one year by Bikewest, showed helmet wearing increasing to around 82% in the post-law years. It was assumed that this rate of helmet wearing was sustained through to 1998 for all types of cyclists (i.e. regular, irregular and occasional). The number of all types of bicyclists were assumed to increase at an annual rate of 1.5%, which has been the population growth rate in Western Australia in the 1990s. A telephone survey conducted in September 1996 in 25 stores in Western Australia that sold bicycle helmets asked sales representatives to estimate how often they thought cyclists replaced their helmets. Helmets were estimated to last for 3.2 years on average. It was assumed that only regular cyclists, namely those who cycle at least once a week, would replace their helmets during the evaluation period. All helmets bought before 1992 were assumed to have been purchased voluntarily (i.e. would have been bought whether or not the legislation was introduced), while those bought in the post-law period until the helmet wearing rate levelled off at around 82% in 1993 were bought involuntarily. Forty-five percent of the post-legislation purchases of new (due to population growth) or replacement helmets after 1993 were assumed to have been bought voluntarily. This latter assumption was based on the fact that 37% of bicyclists were estimated to be wearing helmets in 1991, the year before the legislation, and this increased to around 82% in the post-law period. If it can be assumed that the cyclists who were wearing helmets in the pre-law period bought them voluntarily, then approximately 45% of cyclists (i.e. 37/82=45%) wore helmets voluntarily in the post-law period. The cost of helmets were only included as a cost of the legislation for those cyclists who bought them involuntarily. In the survey of stores selling helmets, respondents were also asked to estimate the average cost of a helmet. This average cost was $39.00. This cost was assumed to have applied throughout the study period.

The final cost to be estimated was the administration cost of the helmet rebate scheme. Bikewest provided this information from its financial records.

Cost-effectiveness of the Bicycle Helmet Legislation
Two measures of the cost-effectiveness of the helmet wearing legislation were calculated: the cost per head-injured cyclist prevented and the Net Present Value of the bicycle helmet legislation, which is calculated as the discounted value of the difference between the benefits and costs of an intervention over the evaluation period. In this study, future benefits and costs were not included in the study, thus there was no need to discount. Benefits and costs were only calculated until 1998, which was base year used for the calculations. In order to convert the number of head injuries (which was the only outcome measured) into a monetary value when calculating the Net Present Value, an average cost of a head injury of $76 900 was applied (Hendrie, Mullan & Ryan, 1999).

Results

Effectiveness of the Bicycle Helmet Legislation - Aggregated Data Model
The results of the least squares regression analysis are presented in Table 3.1. The only variable that was shown to have a significant effect on the ratio of the proportion of bicyclists with a head injury to the proportion of pedestrians with a head injury was the indicator for the helmet wearing legislation. This ratio was modelled as a discontinuous horizontal line. From 1976 to the end of 1991, the modelled ratio was 1.06 (i.e. the proportion of bicyclists with a head injury was on average 6% higher than the proportion of pedestrians with a head injury). From 1992 onwards, this modelled ratio decreased to 0.84 (i.e. the proportion of bicyclists with a head injury was on average 16% less that the proportion of pedestrians with a head injury). The model and the real data are shown in Figure 3.1.

Table .1 Least Squares Regression of Factors Affecting the Ratio of the Proportion of Bicyclists with a Head Injury to the Proportion of Pedestrians with a Head Injury

Variables	Parameter Estimate	Standard Error	F	p
Intercept	1.0691	0.0313	1167.28	0.0001
Indicator for the helmet wearing legislation	-0.2248	0.0567	15.71	0.0007

Two points are worth noting when comparing the modelled ratio with the real ratio. First, a considerable decrease in the real ratio occurred in 1991, the year before the introduction of the helmet wearing legislation. In this year, the available data from the observational surveys of helmet wearing suggested that the overall helmet wearing rate had increased to 37% from 33% in 1990 (calculated from data presented in Baxter & Maisey, 1990 and Dobbs and Maisey, 1991 respectively). Helmet wearing was estimated to have increased to 67% in 1992 and 83% in 1993 (calculated from data presented in Healy and Maisey, 1992 and Heathcote, 1993 respectively). These post-law increases in helmet wearing were only associated with relatively small changes in the ratio of the proportion of cyclists with head injury to the proportion of pedestrians with head injury. Second, in the real data the ratio of the proportion of cyclists with head injury to the proportion of pedestrians with head injury fluctuated fairly widely in the post-law period.

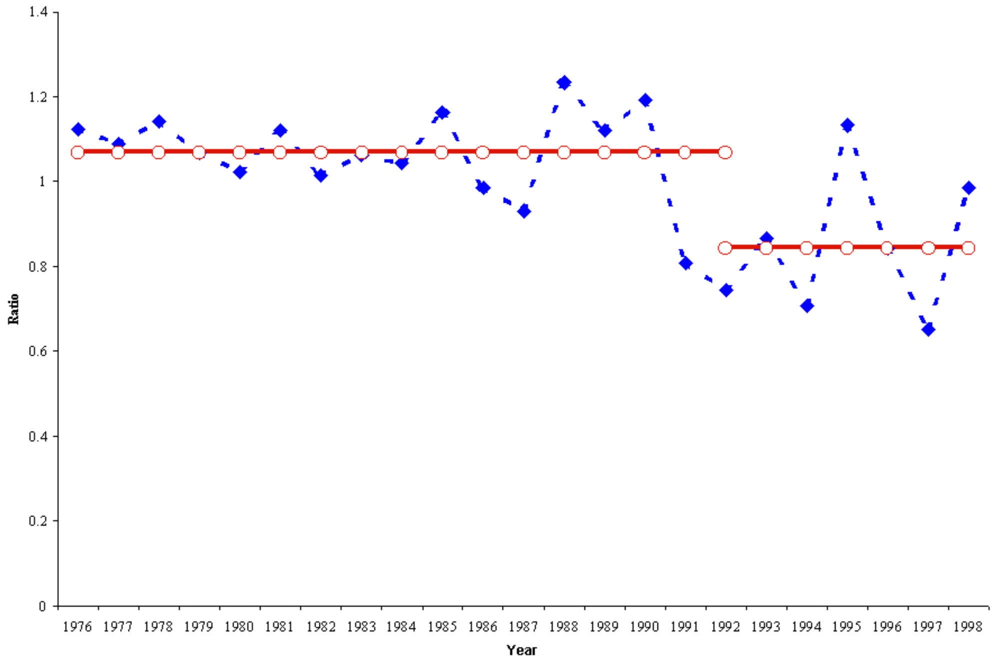

Figure .2 Ratio of Proportions of Bicyclists to Pedestrians with a Head Injury, Western Australia, 1976 to 1998 (Aggregate Data Model)

The least squares regression model can be used to estimate the expected number of bicyclists with head injury between 1992 and 1998 if the helmet wearing legislation had not been introduced. By subtracting the real number of bicyclists with head injury from this expected number, an estimate is provided of the change in the number of bicyclists with head injury due to the legislation (see Table 3.2 and Figure 3.2). This estimated change in the number of bicyclists with head injury fluctuated – from a reduction of 91 bicyclists with head injury in 1997 to an increase of 13 in 1995. Overall, between 1992 and 1998 the number of bicyclists with head injury was estimated to have decreased by 307 due to the helmet wearing legislation, which gives an average annual reduction of head-injured bicyclists of 44 over the period.

Table .2 Estimated Number of Bicyclists with Head Injury without the Legislation, Real Number of Bicyclists with Head Injury, and the Estimated Reduction in the Number of Bicyclists with Head Injury, 1992-1998 (Aggregated Data Model)

Year	**Estimated Number of Bicyclists with Head Injury without the Legislation**	**Real Number of Bicyclists with Head Injury**	**Estimated Reduction in the Number of Bicyclists with Head Injury**
1992	184	129	55
1993	197	161	36
1994	223	149	74
1995	183	196	-13
1996	236	187	49
1997	236	145	91
1998	210	195	15
Total 1992-1998	1 469	1 162	307
Average annual 1992-1998	210	166	44

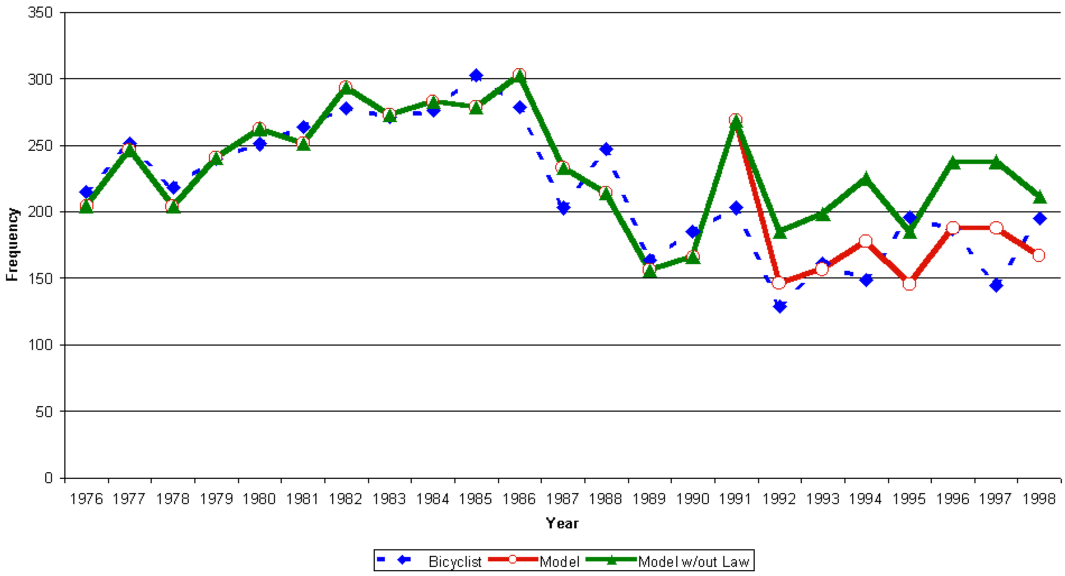

Figure .3 Real Number of Bicyclists Hospitalised with Head Injury and Modelled (Least Squares) Number of Bicyclists with Head Injury with and without the Legislation, Western Australia, 1976 to 1998

Pooled Individual Data Model

The results of the logistic regression analysis using individual data that modelled the likelihood of bicyclists and pedestrians having a head injury are presented in Table 3.3. The age variable was removed from the model as it had a p-value of 0.6118. The likelihood of a bicyclist or pedestrian sustaining a head injury generally decreased over time (OR=0.926) but increased with the time squared variable (OR=1.001). Females had a lower risk of sustaining a head injury (OR=0.885), and over the 23 year period bicyclists were more likely to have sustained a head injury than pedestrians (OR=1.155).

The indicator variables for the start of helmet promotion and the helmet wearing legislation were included in the model because of the interactions. The helmet promotion indicator was protective (OR=0.859), which suggested that bicyclists and pedestrians as a combined group were at lower risk of a head injury in 1986 and in subsequent years after controlling for all the other variables in the model. The helmet legislation indicator was not protective (OR=1.156), which suggests that bicyclists and pedestrians as a combined group were at higher risk of a head injury from 1992 onwards after controlling for all other variables.

The interaction of the road user indicator (i.e. bicyclist) and the helmet promotion indicator was protective (OR=0.886), but was not significant at the 5% level (p=0.0766). The interaction of the road user indicator (i.e. bicyclist) and the helmet legislation was also protective (OR=0.752), and was significant at the 5% level (p=0.0001). This latter indicated that after controlling for time, time squared, gender, road user type (i.e. bicyclist or pedestrian), the start of helmet promotion and the helmet wearing legislation, the effect of the introduction of the helmet wearing law on bicyclists was to reduce the likelihood of a head injury. This finding suggested that the bicycle helmet legislation had an effect in reducing the number of head-injured bicyclists in Western Australia.

Table .3 Logistic Regression of Factors Affecting the Likelihood of Bicyclists and Pedestrians Sustaining a Head Injury

Variables	Parameter Estimate	Standard Error	p	Odds Ratio
Intercept	0.3129	0.0573	0.0001	-
Time	-0.0767	0.0112	0.0001	0.926
Time squared	0.0010	0.0005	0.0372	1.001
Gender	-0.1224	0.0304	0.0001	0.885
Indicator for Bicyclist	0.1443	0.0422	0.0006	1.155
Indicator for helmet promotion	-0.1519	0.0706	0.0316	0.859
Indicator for helmet legislation	0.1454	0.0834	0.0815	1.156
Interaction of bicyclists and indicator for helmet promotion	-0.1206	0.0686	0.0788	0.886
Interaction of bicyclist and indicator for helmet legislation	-0.2855	0.0749	0.0001	0.752

Table 3.4 shows the estimated change in the number of bicyclists with head injury due to the helmet legislation calculated using the individual pooled model. The estimated number of bicyclists with head injury, without the legislation from 1992 to 1998, was derived from the model equation, and the real number of bicyclists with head injury was subtracted from these figures. The estimated reduction in the number of bicyclists with head injury was lower using this individual pooled data model than the aggregate data model. It was estimated that 157 fewer bicyclists sustained a head injury as a result of the helmet legislation from 1992 to 1998, or an average of 20 fewer per year. Figure 3.3 shows the modelled number of bicyclists with head injury with and without the helmet legislation and the real number of bicyclists with head injury.

Table .4 Estimated Number of Bicyclists with Head Injury without the Legislation, Real Number of Bicyclists with Head Injury, and the Estimated Reduction in the Number of Bicyclists with Head Injury, 1992-1998 (Individual Pooled Model)

Year	Estimated Number of Bicyclists with Head Injury without the Legislation	Actual Number of Bicyclists with Head Injury	Estimated Reduction in the Number of Bicyclists with Head Injury
1992	168	129	39
1993	181	161	20
1994	179	149	30
1995	179	196	-17
1996	189	187	2
1997	195	145	50
1998	214	195	19
Total number 1992-1998	**1 305**	**1 162**	**143**
Average annual number 1992-1998	**186**	**166**	**20**

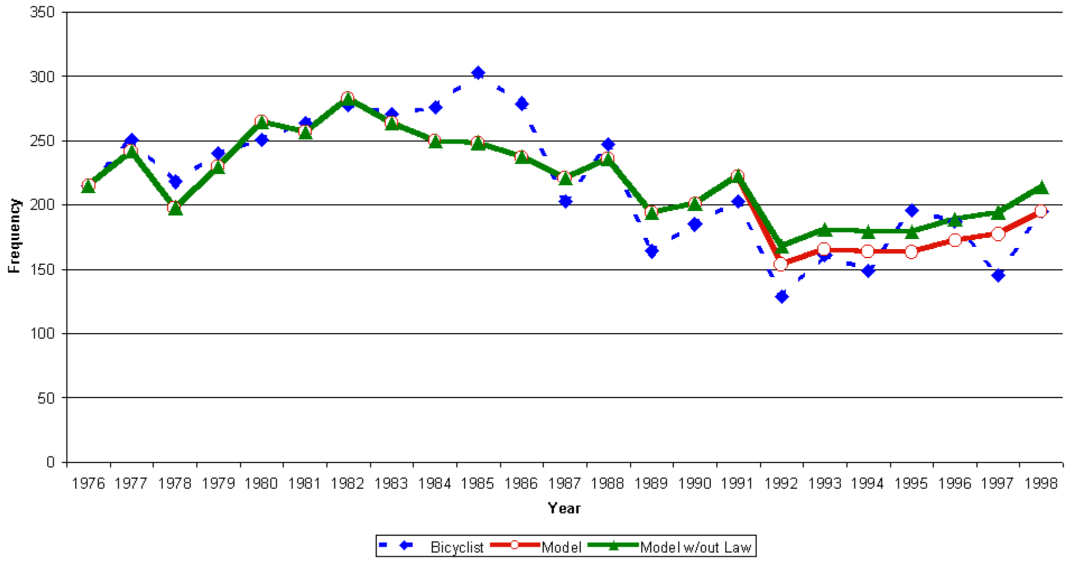

Figure .4 Real Number of Bicyclists Hospitalised with Head Injury and Modelled (Logistic Regression) Number of Bicyclists with Head Injury with and without the Legislation, Western Australia, 1976 to 1998

Costs of the Bicycle Helmet Legislation
Table 3.5 presents the estimated cost of the helmet wearing legislation based on the assumptions and methods discussed in Sections 2.2.1 and 2.2.2. Between 1992 and 1998, the compulsory helmet wearing legislation was estimated to have cost $21.6 million. Purchasing helmets cost $20.2 million, or 94% of this total cost.

This estimate of the cost of the helmet wearing legislation was obviously sensitive to the assumptions made about purchasing helmets. For example, if it was assumed that 45% of the helmets bought in 1992 and 1993 were bought voluntarily and would have been bought without the legislation, then the cost of buying helmets decreased to $13.5 million and the total cost of the legislation decreased to $14.9 million.

Table .5 Estimated Costs of the Bicycle Helmet Legislation

Cost Item	**Expenditure**	
	$000	**%**
Public education campaigns	729*	3.4
Police enforcement	492*	2.3
Purchase of helmets	20 214	93.7
Administration of helmet rebate scheme	146	0.7
Total	**21 581**	**100.0**

* Estimated for later years and to be revised.

Cost-effectiveness of the Bicycle Helmet Legislation
Two measures of the cost-effectiveness of the helmet wearing legislation are shown in Table 3.6. The cost-effectiveness ratio showed a cost per head-injured cyclist prevented of $70 300 if the aggregated data model was used to predict the number of head injuries prevented and $150 900 if the individual pooled data model was used.

The second measure presented the Net Present Value of the helmet wearing legislation. On the basis of the number of head injuries saved using the aggregate data model, the Net Present Value of the legislation was estimated as $2.0 million. If the head injury reductions were estimated from the individual pooled data model, the Net Present Value was estimated as -$10.6 million. This was a wide range, and was sensitive to the underlying assumptions. For example, if the cost of a head-injured bicyclist is assumed to be $45 500 rather than $76 900 – the former is the cost of a moderate head injury (as defined by the Abbreviated Injury Scale) for a hospitalised road crash casualty – then the Net Present Values fell to -$7.6 million and -$15.1 million using the aggregated data and the pooled individual data models respectively. Eighty four percent of hospitalised bicyclists with a head injury had a moderate level of injury severity (Hendrie, Kirov & Gibbs, 1998).

Table .6 Economic Evaluation of the Bicycle Helmet Legislation

Cost-effectiveness ratio		
Cost per head-injured cyclist prevented	Aggregate data model	$70 300 per head injury saved
	Individual pooled data model	$150 900 per head injury saved
Net present value		
Benefits minus costs ($)	Aggregate data model	$2 027 000
	Individual pooled data model	$-10 584 000

Discussion

In this study the helmet wearing legislation was shown to have reduced the number of head-injured bicyclists in the post-law period. Using a method based on aggregated data for each year, the legislation was found to have reduced the number of bicyclists with head injury by 307 from 1992 to 1998. An alternative method based on individual level data found that the number of head-injured bicyclists had decreased by 147 due to the legislation over this period. Depending on which of these methods was applied in the economic evaluation, the cost-effectiveness ratio for the helmet wearing legislation varied from $70 300 per head injury saved to $150 900 per head injury saved. The Net Present Value of the bicycle helmet legislation ranged between $2.0 million and -$10.6 million.

A strength of this study was that it was able to control for the downward trend in the proportion of all road users with head injury over the period. Previous studies have not accounted for this similar, longer term trend for all road user groups, and may have attributed reductions in the proportion of bicyclists with head injury to the helmet wearing legislation when in fact other factors such as a general improvement in road safety accounted for these trends. The study also undertook an economic evaluation, which enabled costs and benefits to be assessed simultaneously. Only two other studies – in New Zealand and Israel – have conducted economic evaluations of bicycle helmet legislation (Ginsberg & Silverberg, 1994; Hansen & Scuffham, 1995). However, neither of these economic evaluations used effectiveness data for helmets collected from their own jurisdictions. In the Israeli study, Ginsberg and Silverberg used a midpoint range of several international estimates of the effectiveness of helmets in reducing mortality and morbidity, while Hansen and Scuffham in the New Zealand study used Seattle and Victorian data on the effectiveness of bicycle helmets (Thompson et al., 1989; Finch et al., 1993).

A difficulty in trying to determine the effectiveness of any road safety countermeasure in reducing the number and/or severity of injuries to road users is that the only source of routinely collected information in Western Australia providing useful injury details is the hospital admissions data collected by the Health Department of Western Australia. This study was therefore limited by this lack of data on less severe injuries (i.e. not admitted to hospital), and the evaluation of the effectiveness of the helmet wearing legislation was not able to take into account any effect of the legislation in reducing the number of cyclists sustaining less severe head injuries not requiring hospital admission. In Victoria, New South Wales and Queensland, motor vehicle personal injury insurers also collect reasonable injury data. Studies evaluating the effectiveness of the bicycle helmet legislation in Victoria have used this data in their analyses (Cameron et al., 1992; Finch et al., 1993; Newstead et al., 1994; Carr et al., 1995).

In terms of the economic evaluation, the study relied on several assumptions about the purchasing of helmets, in particular with regard to the proportion of helmets that would have been bought without the legislation. The assumptions that were made were by necessity arbitrary since little information was available to base them on. Estimates of the cost-effectiveness of the helmet wearing legislation, in particular the calculations of the Net Present Value of the bicycle helmet legislation, were extremely sensitive to changes in these assumptions.

An important limitation of this study was the narrow measure of outcome adopted. The only impact of the bicycle helmet legislation included in the study was the change in the number of cyclists with head injury. This meant that the evaluation was a partial analysis only since the enforced wearing of helmets may have resulted in reduced cycling activity, which could have resulted in the loss of health benefits or negative environmental effects. The health benefits of cycling have been well documented by Roberts, Owen, Lumb and MacDougall (1995).

The findings of this study support those of evaluations in other Australian states that found reductions in the number of cyclists with head injury following the introduction of the bicycle helmet legislation. The magnitude of the decreases suggested by this study are below those found by Carr et al. (1995) in Victoria. Their findings were that the number of bicyclists hospitalised with a head injury had declined by 40% in the first four years of the helmet wearing legislation in Victoria. The findings of the present study suggested smaller reductions of between 11% and 21% in the number of bicyclists hospitalised with a head injury.

The study provided no clear answer as to whether the helmet wearing legislation had been an effective countermeasure in an economic sense. There are no established thresholds against which to measure the value of a cost-effectiveness ratio in the range of $70 300 per head-injured cyclist prevented to $150 917 per head-injured cyclist prevented, and a decision about its net worth must be made by social agreement between policy makers and the community. In monetary terms, it is unlikely that the helmet wearing legislation would have achieved net savings of any sizeable magnitude. Under the assumptions used in the study, the most favourable estimate of the Net Present Value of the bicycle helmet legislation was $2.0 million, and this calculation excluded any costs associated with reduced cycling activity.

Additional study of the wider impact of the compulsory helmet legislation is needed to provide a more comprehensive analysis of the economic implications of the bicycle helmet legislation. Its safety impact in terms of protecting bicyclists from sustaining head injuries could be further explored by extending the analysis undertaken in this study in Western Australia to a national evaluation of the effectiveness of the compulsory helmet wearing legislation in reducing the number of head-injured bicyclists.

REFERENCES

Baxter, M. & Maisey, G. (1990). *Trends in Bicyclist Helmet Wearing in Western Australia: February/March 1990 Survey.* WA Police Department, Perth.

Cameron, M.H., Heiman, L. & Neiger, D. (1992). *Evaluation of the Bicycle Helmet Wearing Law in Victoria during Its First 12 Months.* Report No 32, Monash University Accident Research Centre, Victoria.

Carr, D., Skalova, M., & Cameron, M.H. (1995). *Evaluation of the Bicycle Helmet Wearing Law in Victoria During its First Four Years.* Report No 76, Monash University Accident Research Centre, Victoria.

Dobbs, B. & Maisey, G. (1991*). Trends in Bicyclist Helmet Wearing in Western Australia: February/March 1991 Survey*. WA Police Department, Perth.

Drummond, M.F., O'Brien, B., Stoddart, G.L., and Torrance, G.W. (1997). *Methods for Economic Evaluation of Health Care Programmes, 2nd Edition*, Oxford Medical Publications, New York.

Finch, C.F., Newstead, S.V., Cameron, M.H. & Vulcan, A.P. (1993). *Head Injury Reductions in Victoria Two Years After Introduction of Mandatory Bicycle Helmet Use.* Report No 51, Monash University Research Centre, Victoria.

Ginsberg, G.M. & Silverberg, D.S. (1994). A Cost-Benefit Analysis of Legislation for Bicycle Safety Helmets in Israel. *American Journal of Public Health,* 84(4): 653-656.

Hansen, P. & Scuffham, P.A. (1995). The cost-effectiveness of compulsory bicycle helmets in New Zealand. *Australian Journal of Public Health,* 19(5): 450-454.

Healy, M. & Maisey, G. (1992*). The Impact of Helmet Wearing Legislation and Promotion on Bicyclists in Western Australia*. WA Police Department, Perth.

Heathcote, B. (1993*). Bicyclist Helmet Wearing in Western Australia: A 1993 Review.* WA Police Department, Perth.

Hendrie, D. (1999). *The Cost of Road Injury in Western Australia*. Report No 79, Road Accident Prevention Research Unit, The University of Western Australia, Western Australia.

Hendrie, D., Kirov, C., & Gibbs, S. (1998). *Bicycle Crashes and Injuries in Western Australia*. Report No 60, Road Accident Prevention Research Unit, The University of Western Australia, Western Australia.

Hendrie, D., Mullan, N., and Ryan, G.A. (1999). *The Development of a Road Injury Cost Database*. Report No 92, Road Accident Prevention Research Unit, The University of Western Australia, Western Australia.

King, M. and Fraine, G. (1994). Bicycle helmet legislation and enforcement in Queensland 1991-1993: Effects on helmet wearing and crashes. Paper presented at the 1994 Australian Pedestrian and Bicyclist Safety and Travel Workshop, Melbourne.

Maimaris, C., Sommers, C.L., Browning, C. and Palmer, C.R. (1994). Injury patterns in cyclists attending an accident and emergency department: A comparison of helmet wearers and non wearers. *British Medical Journal*, 308: 1537-1540.

Marshall, J. and White, M. (1994). *Evaluation of the Compulsory Helmet Wearing Legislation for Bicyclists in South Australia.* Report No 8/94, Office of Road Safety, Walkerville, South Australia.

McDermott, F.T., Lane, J.C., Brazenor, G.A., and Debney, A.E. (1993). The effectiveness of bicyclist helmets: a study of 1710 casualties. *Journal of Trauma*, 34: 834-844.

Newstead, S.V., Cameron, M.H., Gantzer, S. & Finch, C.F. (1994). *Bicyclists head injuries in Victoria three years after the introduction of mandatory helmet use*. Report No 75, Monash University Accident Research Centre, Victoria.

Roberts, I., Owen, H., Lumb, P. & MacDougall, C. (1995). Pedalling Health – Health Benefits of a Modal Transport Shift.

Robinson, B. (1996.). *Is there any reliable evidence that Australian helmet legislation works?* Velo Australia International Bicycle Conference, Fremantle, Western Australia.

SAS Institute (1996). *SAS Procedure Guide, Version 6, 3rd Edition*. SAS Institute Inc, USA. Stat Software: Changes

Thomas, S., Acton, C., Nixon, J., Battistutta, D., Pitt, W.R. & Clark, R. (1994). Effectiveness of bicycle helmets in preventing head injury in children: case control study. *British Medical Journal*, 308: 173-176.

Thompson, R., Rivara, F. & Thompson, D. (1989). A case control study of the effectiveness of bicycle safety helmets. *New England Journal of Medicine*, 320: 1361-1367.

Van Ocsh, H.M.J. (1993). An examination of the economic theory of health and safety regulation incorporating a cost effectiveness analysis of bicycle helmets legislation in Western Australia. B. Econ. (Hons.) Thesis, Murdoch University, Western Australia.