MONASH University
Accident Research Centre

BICYCLE USE AND HELMET WEARING RATES IN MELBOURNE, 1987 TO 1992: THE INFLUENCE OF THE HELMET WEARING LAW

BICYCLE USE AND HELMET WEARING RATES IN MELBOURNE, 1987 TO 1992: THE INFLUENCE OF THE HELMET WEARING LAW

by

Caroline F. Finch

Lorna Heiman

& Dina Neiger

February 1993

Report No. 45

ISBN 0 7326 0045 6

MONASH UNIVERSITY ACCIDENT RESEARCH CENTRE
REPORT DOCUMENTATION PAGE

Report No.	Report Date	ISBN	Pages
45	February 1993	0 7326 0045 6	74

Title and sub-title:

Bicycle use and helmet wearing rates in Melbourne, 1987 to 1992: the influence of the helmet wearing law.

Author(s):

Finch, C.F.
Heiman, L.
Neiger D.

Type of Report & Period Covered:

General, 1987-1992

Sponsoring Organisation:

Roads Corporation (VIC ROADS)

Abstract:

From 1987-1992 a series of observational surveys of bicycle usage and helmet wearing in metropolitan Melbourne has been conducted utilising identical survey methodology. This evaluation of the effect of the compulsory helmet wearing law (introduced in July 1990) on both bicycle usage and helmet wearing rates is based on observations made at the 64 sites common to each survey. The mandatory helmet wearing law has achieved its goal of increasing bicycle helmet wearing rates for all groups of bicyclists throughout metropolitan Melbourne. Two years after its introduction, high levels of helmet wearing have been maintained in adults and children. Both adult and teenage rates, in particular, are continuing to increase. The first year following the introduction of the helmet wearing law coincided with a reduction in the number of people riding their bicycles. By 1992, two years after the law, the number of bicyclists was approaching pre-law levels in adults and children but was still greatly reduced in teenagers.

Key Words:
(IRRD except when marked*)

Accident and Danger, age, bicycle, crash helmet,cyclist, evaluation (assessment), exposure*, surveillance.

Contents

APPENDICES:

TABLES:

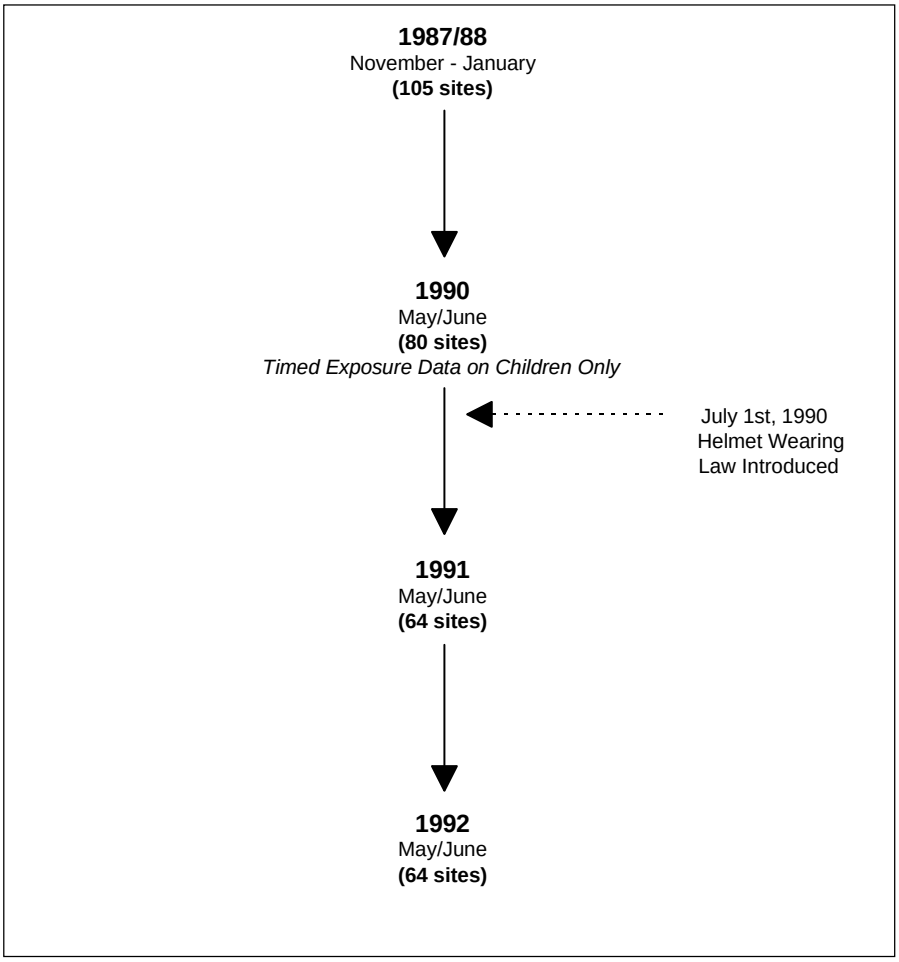
FIGURES:

EXECUTIVE SUMMARY

From the 1st July 1990, Victorian legislation required all bicyclists to wear an approved helmet, securely fastened. The intention of the law was to increase helmet wearing rates for all groups of bicyclists in the State and to reduce the risk of severe head injury to bicyclists involved in crashes. An unintended effect of the law may have been a reduction in the amount of bicycling and the number of bicyclists. The major focus of the present report is to compare bicycle usage and helmet wearing behaviours before and after the introduction of the Victorian law and to describe the observed trends in terms of changes in the risk profile of the bicyclists.

Since 1987, a series of observational surveys of bicycle usage and helmet wearing has been conducted by the Monash University Accident Research Centre (MUARC) for VICROADS (figure 1). Each survey collected data on bicycle use and helmet wearing from a representative sample of bicyclists observed in metropolitan Melbourne during a two-week, non-holiday period over 8am-6pm, seven days a week. Identical survey methodology was adopted during each of the MUARC surveys and the data forming the present evaluation is based on observations made at the 64 sites common to each survey.

Figure 1
Observational Surveys of Bicycle Use and Helmet Wearing

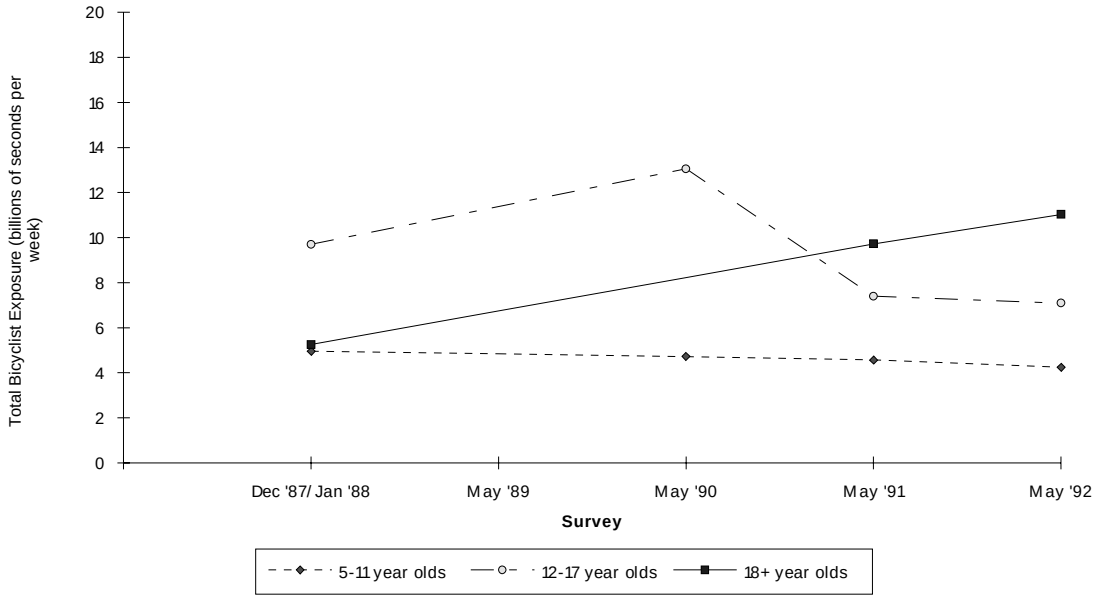


BICYCLE EXPOSURE

Estimation of bicycle use in metropolitan Melbourne indicated that overall total bicycle exposure (billions of seconds per week) had decreased during the survey periods but that adults had increased their exposure (figure 2). Based on the comparison with the first survey in the series, bicycle usage in adults

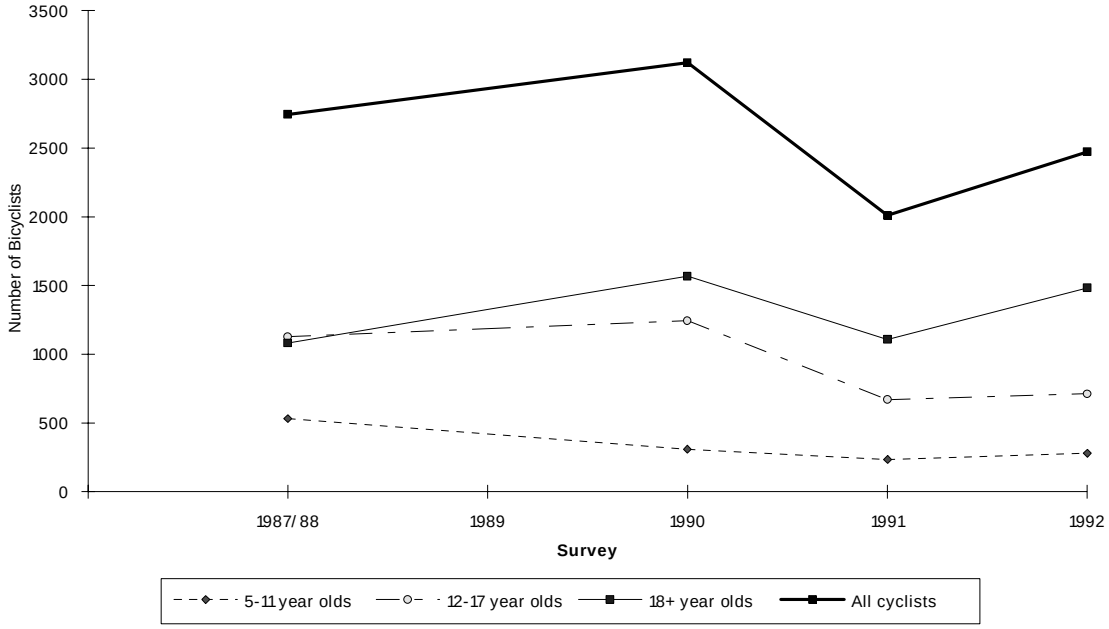
had doubled over the period Nov 1987-May 1992. However, exposure in children (i.e. those aged 5-11 years) in 1992 was 10% less than the pre-law levels assessed in 1990 and teenage exposure had decreased by 46%. The majority of this decrease in teenage (i.e. 12-17 year old) exposure (44%) occurred in the first year after the law was introduced. On the basis of these measurements of bicyclist exposure, it appears that the compulsory helmet wearing law had no deleterious effect on adult bicyclists but that it had a moderate effect on children and a major effect in teenagers immediately after its implementation.

Figure 2
Estimated bicycle use in Melbourne according to age group



Examination of the counts of bicyclists observed during each of the MUARC surveys indicated that there had been a drop in the number of bicyclists during the first year after the law was introduced (figure 3). This drop was greatest in teenagers who might well have been the group most influenced by the helmet wearing law (as evidenced by the fall in timed exposure). The decrease in the number of children was a continuation of the decline in child numbers that was already apparent before the law. Based on these figures, it would seem that the introduction of the law probably had an immediate effect on the number of adult and teenage bicyclists. However, during the period 1991-1992, there was an increase in the number of bicyclists of all ages. As a result of these increases, the number of adult and child bicyclists in 1992 was not much smaller than the observed numbers in 1990. However the number of teenage bicyclists remained considerably less than the pre-law levels.

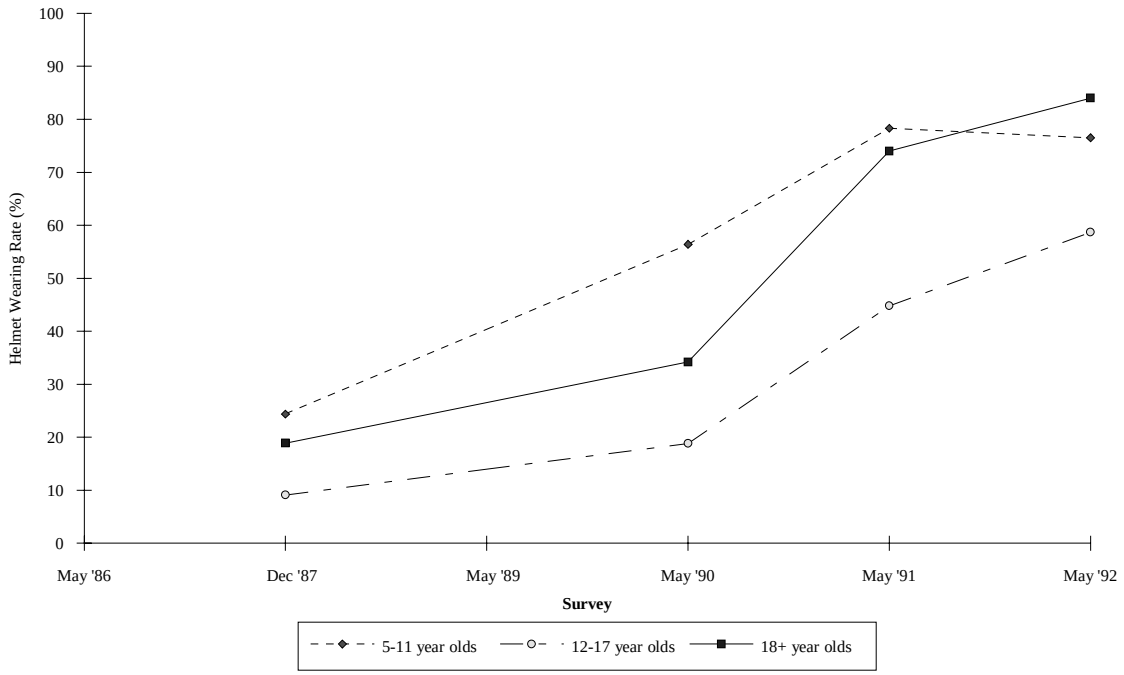
Figure 3
Numbers of bicyclists observed during each of the MUARC surveys



HELMET WEARING RATES IN METROPOLITAN MELBOURNE

There has been a significant post-law increase in helmet wearing rates in all age-groups (figure 4). In children, wearing rates rose from 65% pre-law to a post-law level of 78% in 1991 (77% in 1992). Adult rates rose from 36% in 1990 to 74% in 1991 (84% in 1992). Teenage helmet wearing rates remained the lowest of all three age-groups but had also risen significantly from a pre-law level of 21% to 45% in 1991 (59% in 1992).

Figure 4
Helmet Wearing Rates in Melbourne 1987-1992



HELMET WEARING BEHAVIOURS

During the 1991 and 1992 surveys, information was collected on various helmet wearing behaviours. These included whether the bicyclist was carrying a helmet rather than wearing one, whether the helmetís chin strap was securely fastened and the type of helmet being worn. This information was not available prior to the introduction of the law and so is only a measure of the continuing influence of the helmet wearing law.

By combining the numbers of bicyclists carrying helmets, but not wearing them, with the number of helmet wearers an estimate of helmet ownership has been obtained. Helmet ownership rates decreased from 82% in 1991 to 78% in 1992 amongst children but increased significantly in the other age groups (teenagers from 57% to 65%; adults from 76% to 86%). Amongst helmet owners, there was a slight increase in the proportion of bicyclists wearing helmets in 1992 compared to 1991 for children and adults. In 1991, 20% of teenage helmet owners were carrying rather than wearing them; this decreased significantly to 6% in 1992.

In 1991, one year after the law was introduced, the proportion of helmeted bicyclists (of each age and sex) with their chin straps done up exceeded 97% in all but male teenagers for whom the rate was 94%; by 1992, all rates exceeded 97%.

The 1991 and 1992 surveys indicated that adults tended to wear fewer hard-shell helmets than both children and teenagers. Hard-shell helmets were most common in children. In 1991, 12% of children, 30% of teenagers and 53% of adults wore soft-shell helmets. By 1992, the proportions of soft-shell helmets had fallen in each age-group (11% in children, 27% in teenagers and 42% in adults).

CONCLUSIONS

The mandatory helmet wearing law has achieved its goal of increasing bicycle helmet wearing rates for all groups of bicyclists throughout metropolitan Melbourne. Two years after its introduction, high levels of helmet wearing have been maintained in adults and children. Both adult and teenage rates, in particular, are continuing to increase.

The first year following the introduction of the helmet wearing law coincided with a reduction in the number of people riding their bicycles. By 1992, two years after the law, the number of bicyclists was approaching pre-law levels in adults and children but was still greatly reduced in teenagers.

BICYCLE USE AND HELMET WEARING RATES IN MELBOURNE, 1987 TO 1992: THE INFLUENCE OF THE HELMET WEARING LAW

1. INTRODUCTION

From 1 July 1990, Victorian legislation required bicyclists to wear an approved helmet whilst bicycling. This requirement is specified in the Road Safety (Bicycle Helmets) Regulations 1990, under the Road Safety Act 1986, and provides exemptions for participants in authorised bicycle races and people who would find it extremely difficult to comply with the regulation. An exemption has also been granted to Postal Delivery Officers riding bicycles whilst delivering mail (Leicester et al, 1991). In practice, exemptions have been difficult to obtain and it is understood that fewer than 50 have been granted to date.

Victoria was the first state in the world to introduce compulsory bicycle helmet wearing. The more important activities during the preceding decade which paved the way for this initiative have been described by Vulcan et al (1992). Appendix 1 sets these activities into a timetable of events relating to the use of bicycle helmets in Victoria. Any conclusions about the possible effects of the introduction of the helmet wearing law on bicycling habits need to be considered in the context of this sequence of events.

The law was introduced as a means of increasing helmet wearing practices in all groups of bicyclists in the State. By increasing helmet wearing rates, it was expected that the number and severity of head injuries in bicyclists involved in road crashes would be reduced. However, it was possible that the law could have an unintentional outcome resulting in a reduction in the number of people riding their bicycles.

Since 1987, a series of observational surveys of bicycle usage has been conducted by the Monash University Accident Research Centre (MUARC) for VIC ROADS. Each survey collected data on bicycle use and helmet wearing from a representative sample of bicyclists observed in metropolitan Melbourne during a two week, non-holiday period over 8am-6pm, seven days a week. These surveys have assisted in providing the basis for an evaluation of the effectiveness of the Victorian bicycle helmet wearing law. In particular, they have enabled an examination of whether the new legislation had achieved its goal of increasing bicycle helmet wearing rates for all groups of bicyclists throughout metropolitan Melbourne. An anticipated direct benefit of the law was a reduction in the number and severity of injuries in bicyclists involved in road crashes and this has been evaluated elsewhere (Cameron et al, 1992).

During November - January 1987/88, a survey of 105 sites in Melbourne was conducted to study the relative safety of footpath bicycling; measurements of bicycling exposure, in terms of bicycling time, were also collected (Drummond and Jee, 1988). In May/June 1990, a further survey of a subset of 80 of the sites observed in 1987/88 was undertaken to examine child traffic behaviour (both as pedestrians and bicyclists) in terms of exposure and accident risk (Drummond and Ozanne-Smith, 1991). The 1990 survey focussed on child behaviour and accordingly no timed exposure data was collected on adults. However, the numbers of adults were counted in the same way as the children. Observations of bicycle helmet wearing rates were reported for both children and adults. The importance of the 1990 observational survey was that it was conducted about five weeks prior to the introduction of the bicycle helmet wearing law in Victoria. This means that the 1990 survey provides excellent pre-intervention data on bicycle use in children and helmet wearing in all age groups.

Anecdotal reports suggested that an unintended effect of the compulsory bicycle helmet wearing law may have been a reduction in the amount of bicycling. Because of this possibility, and a need to evaluate the benefits of the law after its introduction, another observational survey of bicycle usage was conducted by MUARC in May/June 1991. This utilised the same methodology used in previous MUARC surveys and was based on a further subset of 64 of the sites previously observed. The 1991 MUARC survey provided post-intervention data on bicycle use and helmet wearing in all age groups.

The results of the pre and post intervention evaluation of helmet wearing rates and bicyclist head injuries have been recently published. In summary, the evaluation found:

> *The mandatory bicycle helmet wearing law implemented in Victoria on 1 July 1990 has been successful in building on past efforts to promote helmet use by bringing helmet wearing rates to new high levels for all bicyclist age groups, both in Melbourne and country Victoria.*
>
> *The introduction of the law has been accompanied by an immediate large reduction in the number of bicyclists with head injuries. Apparently this has been achieved through a reduction in the number of bicyclists involved in crashes (at least partly through a decrease in bicycle use) and a reduction in the risk of head injury of bicyclists involved in crashes. (Cameron et al, 1992)*

The above report did not discuss in detail any possible unintentional side-effect of the law such as a decline in bicycle usage. Although it included a section on bicycle usage results from the 1991 and 1992 (preliminary data) surveys, its focus was on an evaluation of the pre- and post-law helmet wearing rates and the corresponding reduction in bicyclist injuries. However, as pointed out by Cameron et al, one possibility is that the reduction in bicyclist head injuries could be partially attributed to fewer people riding their bicycles (Cameron et al, 1992). With a reduction in the number of bicyclists, it would be expected that there would be fewer bicyclists involved in crashes.

A similar pattern of outcomes following introduction of a helmet wearing law has also been observed in New South Wales. An evaluation of law compliance and numbers of bicyclists in New South Wales after implementation of a compulsory bicycle helmet wearing law in that State has recently been completed (Walker, 1992). Unlike the situation in Victoria, the helmet wearing law was implemented in two stages - as of 1 January 1991, all bicyclists aged sixteen years of age and older were required to wear helmets; from 1 July 1991, this requirement was extended to bicyclists of all ages. Evaluation of the effectiveness of the introduction of the two stage law was based on a series of observational surveys conducted during the Easter school vacation period. Following implementation of the law, helmet wearing rates had risen dramatically and the number of bicyclist fatalities had decreased by 59% (Walker 1992; Walker 1991; Roads and Traffic Authority, 1991). However, the evaluation also found that the number of child bicyclists during the Easter school holidays had decreased by 36%. Despite an apparent initial increase (6%) in the number of adult bicyclists, an assessment of bicycle use 16 months after its introduction showed that adult bicyclist numbers had also decreased (by 14%).

The major focus of the present report is to compare bicycle usage in metropolitan Melbourne before and after the introduction of the Victorian law and to describe the observed trends in terms of changes in the risk profile of bicyclists. The 1991 MUARC survey was repeated in May/June 1992 as a means of assessing whether the bicycle usage and helmet wearing rates assessed in 1991, one year after the

implementation of the law, had been maintained over a longer period of time. A detailed description of the findings of the 1991 and 1992 MUARC observational surveys will also be given.

2. OBJECTIVES

Based on the results of the MUARC series of surveys, the objectives of the current report are to:

- present the results of the 1991 and 1992 observational surveys and to compare these to the two earlier surveys;
- investigate bicycle helmet wearing rates two years after the introduction of the bicycle helmet wearing law;
- assess the quality of helmet use in terms of whether the chin strap is done up or not;
- determine the proportion of soft-shell helmets in use;
- determine whether bicycle use has decreased following the introduction of the compulsory bicycle helmet wearing law; and
- describe the trends in bicycle use in terms of trends in the profile of those at risk of accident involvement.

3. BACKGROUND TO THE MUARC OBSERVATIONAL SURVEYS OF BICYCLE USE AND HELMET WEARING

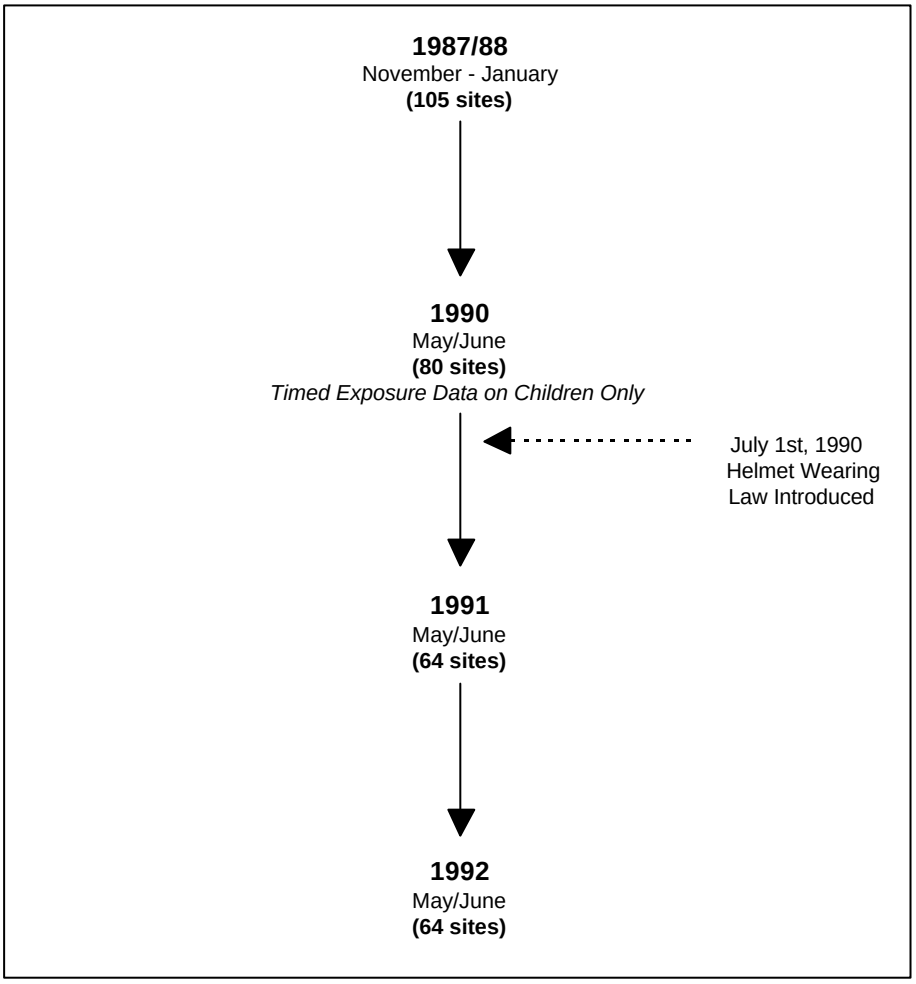
Figure 1 summarises the time frame of the MUARC observational surveys of bicycle usage. With the exception of the 1987/88 survey, all observations were made during the months of May/June. The 1990 survey collected timed exposure data on children only, although bicycle helmet wearing was recorded in adults. Not withstanding these limitations, this series of surveys can be used to draw comparisons between bicycle use prior to the law and after its implementation, particularly in children under 18 years of age.

The 1987/88 survey was commissioned by the then Road Traffic Authority and the State Bicycle Committee. The motivation behind it was a need to provide an empirical basis for policy decisions on the possible legalisation of footpath bicycling for specific bicyclist groups and/or specific locations. An assessment was made of the relative safety of bicycling on the road and footpath and of a variety of different bicycling behaviours that might put bicyclists at increased risk of accident involvement.

VIC ROADS sponsored the 1990 study in response to the Social Development Committee of the Victorian Parliament identifying a need for exposure data for children in traffic (Social Development Committee, 1987, Recommendation No 38). The study was timed so as to be conducted prior to the introduction of the compulsory helmet wearing law. It was intended that the results would assist in setting priorities for appropriate intervention strategies to prevent injuries to child pedestrians and bicyclists. The data collected also formed the ideal basis upon which a pre-post intervention type evaluation of the helmet wearing law could be designed. For this reason, adult helmet wearing data was also collected.

Following the introduction of mandatory helmet wearing, it was necessary to conduct an evaluation of the effectiveness of the law in achieving its specified goals. For this reason, and because it was felt that an unintended effect of the law might have been a reduction in bicycle use, an observational survey of bicycle usage was conducted by MUARC in May/June 1991. This survey, performed at the same time

Figure 1
Monash University Accident Research Centre (MUARC) observational surveys of bicycle use and helmet wearing



of the year as the 1990 survey, provided information about bicycle helmet wearing habits almost one year after the law was introduced.

The survey in 1992 was designed to assess whether the behavioural changes (both with respect to bicycle use and helmet wearing) observed one year after the introduction of the law were being maintained.

In order to make valid comparisons between the observational data collected during the 1991 and 1992 surveys and that collected prior to the introduction of the law, identical survey methodology was employed for each survey. Since a major determinant of bicycle use is season of the year, the 1991 and 1992 surveys were conducted during the same time of year as the 1990 survey. Further details of the survey methodology for the earlier surveys are given in Drummond and Jee (1988) and Drummond and Ozanne-Smith (1991).

4. SURVEY METHODOLOGY

4.1 SELECTION OF THE SURVEY SITES

Because the majority of bicyclist casualty crash involvements occur in the Melbourne Statistical Division, the 1990 MUARC survey restricted itself to the metropolitan area. A subset of the regions used in the 1987/88 footpath bicycling study was selected for use in the 1990 exposure survey. Of the 105 sites observed in 1987/88, 80 were re-visited in 1990. Full details of the selection of this subset are described in Drummond and Ozanne-Smith (1991). To enable valid comparisons, these same regions also formed the basis for site selection in the 1991 survey (figure 1).

Because of logistic, costing and time constraints, the 1991 survey was based on 64 randomly selected sites in the Melbourne metropolitan area. These were chosen to be a subset of the 80 sites observed in the 1990 survey. Sites were drawn from five regions around Melbourne, representing the total metropolitan area. The selection process was conducted in such a way that the form of the weighting factors for scaling up the observations from each region to the whole of Melbourne was the same as for the earlier surveys (see Section 4.6). This means that the estimates of total bicycle exposure in Melbourne (in seconds of bicycling per week) from the 1991 survey are directly comparable to the estimates derived from the earlier surveys described above.

The 1992 survey was based on observations of the same 64 sites used in the 1991 survey.

Appendix 2 lists the full set of sites observed during the series of MUARC exposure studies. The subset of 64 sites observed in 1991 and 1992 (and hence included in each of the four surveys) are clearly indicated in this Appendix.

Table 1: Regions and local government areas (LGAs) sampled in the 1991 and 1992 surveys

Region				
North West	**North East**	**Outer Eastern**	**Inner South Eastern**	**Southern**
Broadmeadows	Northcote	Croydon	Port Melb.	Brighton
Keilor	Preston	Ringwood	South Melb.	Sandringham
Sunshine	Heidelberg	Doncaster /Templestowe	Fitzroy	Caulfield
Altona	Diamond Valley	Box Hill	Richmond	Malvern
Williamstown	Kew	Nunawading	Prahran	Oakleigh
Footscray	Hawthorn	Knox	Collingwood	Moorabbin
Essendon	Camberwell	Waverley	St Kilda	Springvale
Coburg		Berwick		Dandenong
Brunswick				Mordialloc
				Chelsea
				Frankston

Specific information relating to the 64 sites observed in 1991 and 1992 are given in Table 1 and Table 2. Table 1 shows the local government areas that the 64 observation sites represent. The actual total road lengths in each region are given in Table 2. These are important because the weights involved in the scaling up procedure are based on knowledge of these road lengths (see Section 4.6).

Table 2: Total road length by type of road in each region (in kilometres)

	Region				
Road Class	**North West**	**North East**	**Outer Eastern**	**Inner South Eastern**	**Southern**
Arterial	401	272	481	150	490
Non-arterial (local)	2597	1795	2875	693	2743
Total	2998	2067	3356	843	3233

Table 2 also indicates that, within regions, road types were classified as either arterial or non-arterial (ie local). This was necessary because the risk of crash involvement, the location of bicycle use (whether on road or footpath) and bicycling behaviour is different for the two classes of road. Furthermore, based on the proportion of the total road network they account for, arterial roads witness more crash involvements than would be expected. For this reason it was considered appropriate to over-sample arterial road sites.

Sites were sampled from the 5 regions of metropolitan Melbourne according to that region's share of the total road network. Arterial road sites were over-sampled by a factor of 3. This resulted in the allocation of sites to regions and road class as shown in Table 3.

Table 3: Allocation of sites across regions and road class in 1991 and 1992

	Region					
Road Class	**North West**	**North East**	**Outer Eastern**	**Inner South Eastern**	**Southern**	**Total**
Arterial	5	3	6	2	6	22
Non-arterial	9	8	11	3	11	42
Total	**14**	**11**	**17**	**5**	**17**	**64**

4.2 DEFINITION OF OBSERVATION ZONES

For each MUARC survey, the same definition of observation zone (site) was used:

Observation zone: a length of road stretching from the far side of the selected intersection (if applicable) to a pre-determined boundary (contingent on road geometry).

Observation zones were categorised as arterial or non-arterial. Appendix 3 provides a diagrammatic representation of the definition of observation zones into one of these two classes of roads. The definition of an arterial observation zone was that of a length of road including the intersection of two arterial roads. However, non-arterial zones were defined as occurring in one of two ways:

- two intersecting non-arterial roads. In this case the non-arterial zone included the intersection; or
- intersecting arterial and non-arterial roads. In this case the observation zone was located in the non-arterial road and excluded the intersection.

This definition was necessary because the population of all possible sites had to be defined in such a way that they did not overlap and double-count parts of the road system.

4.3 OBSERVATION PERIODS AND TIMES

The surveys were conducted on seven days a week over a two week period. In 1991, this period commenced on 26 May. In 1992, the two week observation period began on 22 May. Like the earlier MUARC surveys, the observation periods were constrained to occur during weeks that did not contain any public or school holidays.

For observational purposes, four time blocks were defined - weekday morning, weekday afternoon, weekend morning and weekend afternoon. Each of these blocks were of five hours duration. Observation sessions were held in the morning from 8am to 1pm and in the afternoon from 1pm to 6pm. Most sites were observed over 2 sessions of 5 hours each. In 1991 and 1992, one site (1991/92 Site no. 15, Appendix 2), was observed over three sessions. Site 16 was observed only once in 1992. This resulted in a total of 129 sessions in 1991 and 128 sessions in 1992 representing 640 hours of observation.

Data was collected for only 50 consecutive minutes of every hour to ensure that observers applied their full concentration to the task for the duration of the observation period.

If another bicyclist was seen riding through the zone at the same time as one was already being observed, the second bicyclist's age, sex and helmet wearing status were recorded, even if their exposure time could not be measured. When the latter situation occurred, the average bicycling time (for bicyclists of the same age group observed within that region and road class) was assigned to those bicyclists for data analysis purposes (see Section 4.6).

4.3.1 Police Enforcement of Bicycle Laws During the 1991 Survey Period

A bicycle safety seminar was held in Geelong on 29 April 1991 to raise awareness of the importance of bicyclist compliance with road laws. This seminar was attended by representatives of most of the metropolitan police districts.

During the two week May/June survey period only a few police districts had increased their enforcement effort towards improving bicyclist road behaviour. Since their targeting of bicyclists was only in the preliminary stages at the time of MUARC's survey, it is believed that these actions would not have had any significant effect on the bicycling behaviour of those people observed during the survey.

4.4 DATA COLLECTION

Bicyclists were observed by trained observers and recordings of their helmet wearing and bicycling behaviours were reported on a data collection form in a standardised way. Appendix 4 gives a copy of the 1992 data collection form; this was identical to the one used in 1991. The data collection forms were designed to be as self coding as possible to minimise errors at the data coding phase of the project.

Information recorded was of four types:

- characteristics of the observation zone
- measures of exposure
- demographic details
- helmet wearing habits.

Some additional information was collected during the 1987/88 and 1990 surveys. This current report is concerned only with that information which was consistently collected during each one of the four surveys. The reader is referred to the reports by Drummond and Jee (1988) and Drummond and Ozanne-Smith (1991) for details of the additional information gathered in the earlier surveys.

It was emphasised during training that the items of information that required the observers' greatest attention and accuracy were the age, sex and helmet wearing status of the bicyclists passing through their observation zone.

4.4.1 Characteristics of the Observation Zones

During each of the surveys, characteristics of the observation zone itself were collected. A Site Summary Form was used to collect this information in a standardised manner. A copy of the 1992 form is in Appendix 4; this was identical to the 1991 form.

Specifically, data was collected on:

·	site number	
·	length of the observation zone (needed for the weighting procedure)	
·	road class	arterial
		non-arterial (local)
·	land use	residential
		shops
		industrial
		parks/school/pre-school
		other
·	weather conditions	fine
		rainy
·	date	
·	day of week	
·	time block	weekday AM
		weekday PM
		weekend AM
		weekend PM

Operational definitions for these data items were explained to all observers during training. A copy of these are included in Appendix 5.

4.4.2 Measures of Exposure

As in the earlier surveys, data was collected for two measures of exposure:

· time spent on road and/or footpath

· whether road entries (ie departures from the footpath) were made at an intersection or at a point somewhere in the middle of the block.

For each bicyclist entering the observation zone, the amount of time spent on the road was recorded in seconds. Similarly, the amount of time spent on the footpath (seconds) was also recorded. These two time recordings were added to obtain a total exposure figure for each bicyclist. Bicyclists were only timed whilst moving on the road or footpath. As explained in Section 4.6, an estimate of total exposure in metropolitan Melbourne was able to be based upon a suitable scaling up of these individual exposures.

The road entries were recorded as a measure of "more at-risk" behaviour. Road entries mid-block are generally considered to be more hazardous for bicyclists than intersection entries.

These exposure measures could be linked to the characteristics of the observation zones so that the influence of confounding factors, such as weather conditions, on exposure could be assessed.

A copy of the operational definitions of exposure given to the observers is in Appendix 5.

4.4.3 Demographic Details

Observers were asked to record the sex and estimated age of the bicyclist. Training of the observers focussed in detail on the estimation of bicyclist ages. Difficulties that had been identified during the earlier surveys were addressed during the training sessions. Observers were required to record bicycling behaviour in bicyclists aged at least 5 years of age.

4.4.4 Helmet Wearing Behaviours

Information was collected on whether or not bicyclists were wearing helmets. When helmets were being worn, it was also recorded if the chin strap was fastened. Observers were trained to fill in a response in this part of the form only if the bicyclist was wearing a helmet. For non-helmet wearing bicyclists, this section was kept blank.

Some bicyclists who did not wear helmets carried them on their bicycles. When a bicyclist exhibited this behaviour it was also noted on the form. Generally, if a bicyclist was wearing a helmet the issue of whether or not he/she carried one was not applicable.

The type of helmet worn was recorded as being either hard-shelled, soft-shelled (i.e. foam only or micro-shells) or of another type. If the bicyclist was not wearing a helmet, the observers were trained to leave this section of the data collection form blank as this observation was irrelevant.

Operational definitions for the recording of helmet wearing behaviours were given to all observers. A copy of these are given in Appendix 5.

4.5 THE OBSERVERS

In 1991, a total of fourteen observers was recruited among graduate and under-graduate students at Monash University. Twenty observers were recruited by the same means in 1992. A single observer was allocated to each site.

Each observer was provided with a Letter of Authority stating that he/she was an employee of MUARC and the purpose of the survey. This letter was to be shown to concerned members of the public who were then referred to the survey supervisor if they had further questions about the intent of the survey.

A letter was also sent to the Officer in Charge of the Police districts represented in the survey regions. This was to inform them of the nature of the MUARC survey and the presence of trained observers at sites within their districts. Once again, concerned people were referred directly to the survey supervisor.

4.5.1 Training of the Observers

All observers were required to participate in an intensive and interactive training session. This was based on a training video that was filmed on location near a suburban primary school in 1990. The

primary school video was supplemented by a video of bicyclists passing near a secondary school in 1991.

The two videos were accompanied by explanatory notes and worksheets. The observation tasks and operational definitions of the survey (Appendix 5) were explained in depth and the observers trained in all aspects of the observational methodology. The video training involved the viewing of certain sections of the videos together with the explanatory notes giving details of the bicyclists' age and sex; examples of the timing of bicycle exposure were also included. Observers then participated in exercises requiring them to undertake the required timing of road entries and bicycling and the completion of data collection sheets. These exercises were based on several (previously unviewed) sections of the video which demonstrated the range of tasks that they would be required to undertake in the field.

In addition to the training sessions, observers were visited by one of the survey supervisors on site during their first observation session so that any outstanding questions could be answered. The survey supervisors also visited observers at various times during the study to ensure that the survey protocol was being adhered to.

4.5.2 De-briefing Sessions

After the 1991 survey, a de-briefing session was held for all observers. A questionnaire seeking observer reports of the survey procedure and operation was distributed. Appendix 6 gives a summary of the observers' reports.

4.6 STATISTICAL METHODS

The data presented in this report is only for bicyclists whose age was recorded as being at least 5 years. Furthermore, to enable the most powerful estimates of trends in bicycle exposure and helmet wearing rates to be computed, the results from the 1987/88 and 1990 surveys presented here are restricted to the 64 sites observed during each stage of the full MUARC survey series. In other words, bicycle use was assessed pre- and post-intervention on the basis of change in the same 64 sites observed during each of the MUARC surveys.

4.6.1 Data Processing

All data collection forms were sent to data-entry professionals for entering onto the computer. All data was validated and verified prior to any analysis. A process of double entry was used to minimise data-entry errors and extensive consistency checks were performed. The SPSS PC+ statistical analysis package was used to analyse the data.

Subsequent additions or alterations to the data were made to the SPSS system files and not to the raw data sets themselves to preserve the integrity of the original data.

4.6.2 Estimating Exposure

The major objective of each survey was to estimate the total bicycle use in Melbourne. For this reason, the surveys were designed in a such a way that the "best" estimate of total bicycle use in metropolitan Melbourne could be calculated on the basis of recordings in the specific observation sites.

A sampling fraction was devised which accounted for the relationship between the length of the observation zone and the total length of the road network (either arterial or non-arterial roads) in the particular region surveyed. The weighting factor also accounted for the relationship between the

number of times a specific time block was sampled in a particular region and the total number of those specific time blocks in a week.

Specifically, the weighting of road exposure was of the form:

wtexp _ rd = rnd ((timerd * regleng * timefact * yearfact * 6) / (sampzone * zonel * 5))

where

wtexp_rd	is the weighted exposure on road;
timerd	is the observed time on road;
regleng	is the total road length (in metres) of a region calculated separately for arterial and non-arterial roads;
timefact	scales the 4 time blocks up to a standard week by assigning a weight of 2 or 5 according to whether the bicyclist was observed on a weekend or weekday, respectively;
yearfact	takes the value of 47.7 and corresponds to the number of non-holiday weeks in a year. (For the purpose of the exposure calculations, the holiday period consists of 31 days out of 365 days in a year.) Thus this factor scales weekly exposure up to an annual (non-holiday period) estimate;
sampzone	adjusts the resultant exposure figure for the number of times that a particular time block (five hour observation period) was sampled within a region and road class;
zonel	is the road length (in metres) of the observation zone;
the ratio 6/5	scales the 50 minute sessions up to 60 minute periods.

The SPSS function "rnd" rounds the resulting calculation to the nearest integer. This was to preserve the precision of observer recordings of time (time was recorded to the nearest second). The weighting of the footpath cycling time was performed in an identical manner but with *timefp*, the observed time on the footpath, used instead of *timerd*.

The weighting of the sample data enabled it to be scaled up to regional data. Regional estimates were then aggregated to provide an estimate of exposure for the entire study area. Full details of the weighting procedure are given in Drummond and Jee (1988). Although the number of times a specific time block was sampled in a particular region differed throughout the survey series (because of the greater number of sites in the earlier surveys), the weighting procedure enabled comparable exposure estimates from each survey to be obtained. Time block allocations were identical in 1991 and 1992.

4.6.3 Assessing Changes in Bicycle Use

Two approaches were used to assess changes in bicycle use over the period of time covered by the MUARC surveys:

a) Exposure estimates

The sampling frame of the series of surveys was chosen so that computed estimates of bicycle exposure (in seconds of bicycling per week) were directly comparable across all studies. Because timed exposure was not measured in adults in 1990, this section of the results compares changes in exposure across all four surveys in bicyclists under the age of 18 years only. Pre- and post- intervention

comparisons of exposure in adults was therefore made on the basis of the 1987/88 survey instead. However, the data forming this comparison was collected at different times of the year and there was nearly 3.5 years between the earlier survey and the one in 1991. Conclusions drawn from an evaluation of trends in adult exposure on this basis must therefore be interpreted with caution.

b) The number of bicyclists

As an additional means of assessing the effect of the helmet wearing law on bicycle use, an examination of trends in the number of bicyclists observed during each survey was undertaken. Changes in the numbers of bicyclists in all age groups was able to be based on all four surveys. Although timed exposure measurements were not made in adults in 1990, the number of adults wearing/not wearing helmets during that survey was recorded. This means that a comparison of adult counts during the 1987/88, 1990, 1991 and 1992 surveys gives an indication of adult exposure trends. However, undue importance should not be attributed to interpretations based on comparisons with the 1987/88 survey because of the almost four years time gap between this survey and the post-intervention surveys and the different times of the year.

4.6.4 Missing Values

The data presented in this report refers only to people aged five years or more. There was a very small number of observed bicyclists whose age was not recorded. Such individuals have been excluded from the data in this report. The proportion of such missing cases did not vary substantially between the 1988/89, 1990 and 1992 surveys (an average of .5%). In 1991, the proportion of missing cases was 4%.

Similarly cases with a missing recording of any one of the demographic variables or helmet wearing status being considered in a particular statistical analysis were omitted for that particular calculation.

When exposure variables (time on the footpath or time on the road) were being considered, bicyclists with missing exposures were assigned the average exposure of all bicyclists of the same age. This substitution was made on a region and road class specific basis and took into account the number of bicyclists with both zero and non-zero exposures on either the footpath or road.

4.7 TERMINOLOGY

For the purposes of data analysis, ages were categorised into three groups: 5 to 11 years, 12 to 17 years and 18 years and over. In the text of this report, these three groups of bicyclists are referred to as children, teenagers and adults, respectively.

Location of bicycling is a measure of exposure risk and is quantified here in terms of footpath or road bicycling. For the purposes of this study, a bicyclist is said to be a footpath bicyclist if a timed exposure on the footpath was recorded. Similarly, road bicyclists are those for whom a timed exposure on the road was noted. Because some bicyclists travelled on both the footpath and road whilst under observation, footpath and road bicyclists are not necessarily mutually exclusive groups. However, by treating these two categories separately, the possibility of bicyclists taking off their helmets when riding on the footpath but retaining them on the road (or vice versa) should not complicate the results.

5. RESULTS

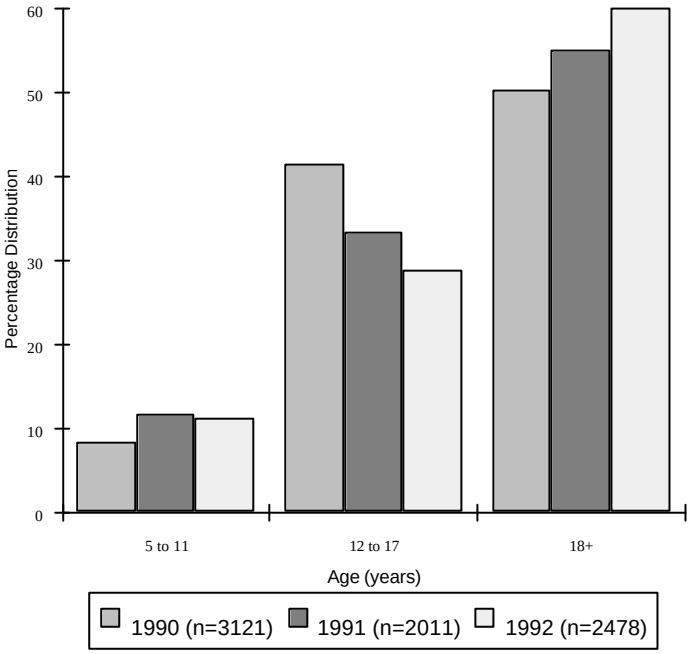
5.1 DESCRIPTION OF THE CHARACTERISTICS OF THE OBSERVED SAMPLES OF BICYCLISTS IN THE 1991 AND 1992 SURVEYS, COMPARED TO 1990

The number of bicyclists recorded in the 64 observations sites in 1991 was 2011. In 1992, 2477 bicyclists were observed in these same sites during the same time of day.

5.1.1 Age and Sex Distributions

The ratio of the number of males to females was fairly constant in the two post-law surveys. On average, males comprised 86% of all observed bicyclists and females 14%. This sex ratio is the same as that found in 1990 (Drummond and Ozanne-Smith, 1991).

Figure 2
Age distribution of bicyclists



The overall age distributions of bicyclists observed during each survey are given in figure 2. As a proportion of the total, there were fewer teenage bicyclists in 1992 than in 1991 (29% versus 33%). Conversely, the proportion of adult bicyclists was higher in 1992 than in 1991 (60% versus 55%).

Figure 2 also compares the post-law age distributions with those observed in 1990. Prior to the law, children accounted for 8% of all bicyclists, teenagers 41% of all bicyclists and adults 50% of the total. Thus, whilst the age trend was consistent across all surveys, teenage bicyclists were a greater proportion of the total number prior to the introduction of the helmet wearing law.

For females, the age distributions were quite similar across the 1991 and 1992 surveys with more child and teenage bicyclists observed in 1992 than in 1991 (figure 3). In 1992, the percent of adults was 54%, a decrease from the figure of 61% observed in 1991. Prior to the law, there were equal numbers of adults and teenagers and proportionately more teenagers than at the later surveys.

Comparison of the 1991 and 1992 male age distributions (figure 4) show that the proportion of child and teenage male bicyclists had gone down in 1992, compared to 1991, but that the adult percent had risen from 54% to 61%. Despite this, the proportion of male adults and children was greater post-law than in 1990. However, there were fewer teenagers in 1991 and 1992 compared to the proportions observed prior to the helmet wearing law.

5.1.2 Road Class Distributions

The distribution of bicyclists according to road class in 1990, 1991 and 1992 is shown in figures 5 and 6. In 1990 and 1991, 40% of all bicyclists were observed on non-arterial roads. By 1992, this had dropped to 30%. During all surveys, adults were clearly the major users of arterial roads (62% of all arterial road users in 1990, 65% in 1991 and 73% in 1992). Children accounted for less than 7% of all arterial road users in both surveys.

Figure 3
Age distribution of female bicyclists

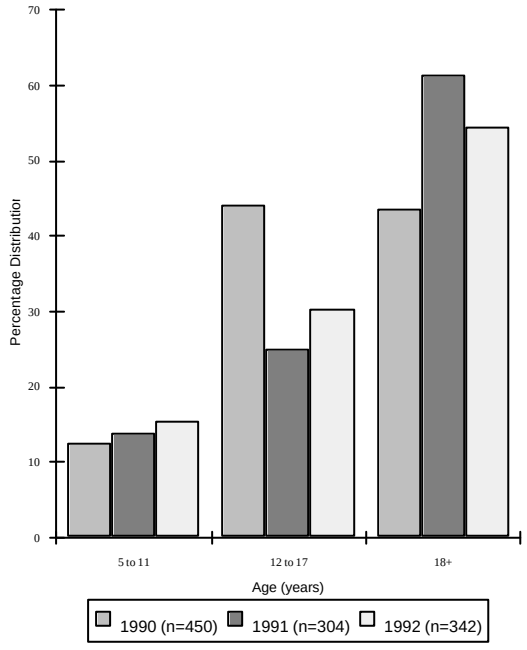
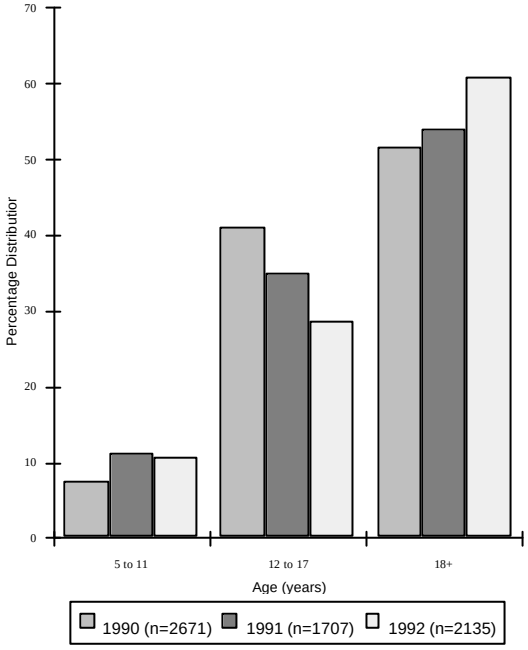


Figure 4
Age distribution of male bicyclists



In 1990, more than half of the non-arterial road users were teenagers (52.1%). In 1991, this had dropped to 40% and rose to 45% in 1992. The proportion of child non-arterial bicyclists increased after the law was introduced (15% in 1990, 20% in 1991, 25% in 1992). Adult use of non-arterial roads increased from 33% prior to the law to 40% in 1991 but fell to lower levels in 1992 (31%).

5.1.3 Time of Week Distributions

Table 4 summarises the distribution of bicyclists according to the time of the week (ie. time block) during which they were observed. During each survey, the greatest proportion of bicyclists were observed on weekday afternoons and the least on weekend afternoons. In 1990 and 1991, more bicyclists were observed on weekday mornings than on weekend mornings. The converse was true for 1992.

Figure 5
Age distribution of bicyclists observed on non-arterial roads

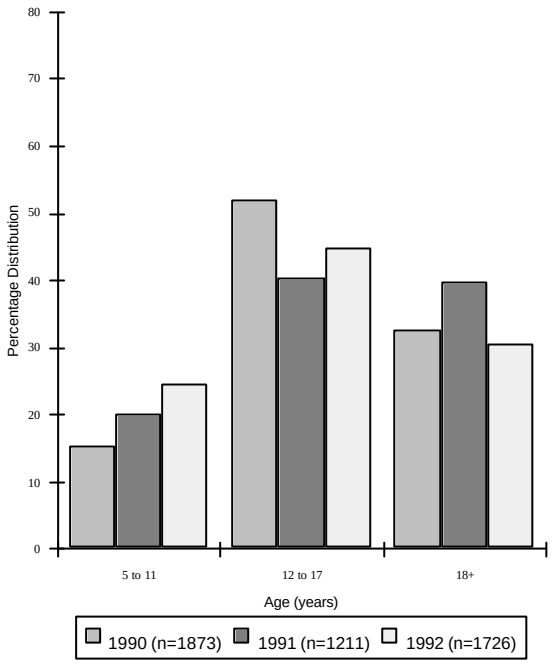


Figure 6
Age distribution of bicyclists observed on arterial roads

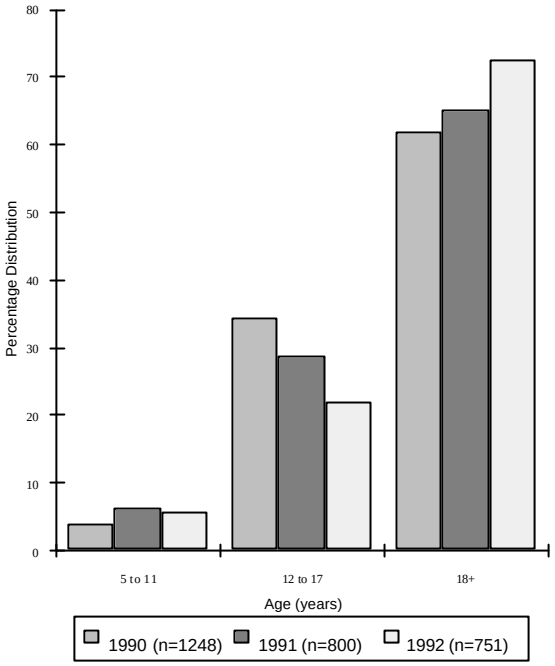


Table 4: Time block distribution for bicyclists observed in 1990, 1991 and 1992

	% of bicyclists		
Time of Week	**1990 Survey**	**1991 Survey**	**1992 Survey**
Weekday AM	27	28	21
Weekday PM	34	43	30
Weekend AM	24	15	29
Weekend PM	16	14	20

Table 4 also shows a shift in distribution from weekday to weekend bicycling. In 1991, there were more bicyclists on weekdays (both mornings and afternoons) and considerably fewer on weekend mornings, compared to 1990. In 1992, the time block distribution was similar to that in 1990.

5.2 HELMET WEARING RATES

During each of the MUARC bicycle use surveys of a representative sample of bicyclists in Melbourne, data was collected on helmet wearing rates. The 1990 survey, whilst not measuring bicycle use in adults, still collected information on helmet wearing rates in this age group.

Cameron et al have recently reported an evaluation of the effect of the introduction of the mandatory helmet wearing law on helmet use during the first 12 months since its introduction in Victoria (Cameron et al, 1992). This evaluation combined data from a series of different surveys of helmet use conducted

by VIC ROADS. The combined data was used to estimate trends in overall wearing rates in Victoria. Full details of each of the different types of surveys and the method for combining the data can be found in the study report. The evaluation found that average wearing rates for bicyclists in Victoria rose from 5% in 1982/83 to 31% in 1989/90 and then to 75% in 1990/91 following introduction of the helmet wearing law. Interpretation of these trends should be made in the light of the full timetable of events that could have influenced helmet wearing over that period; these are detailed in Appendix 1.

Figures 7-9 update the results of the Cameron et al report for Melbourne by adding the 1992 MUARC survey helmet wearing results to the summary figures presented in it.

5.2.1 Comparison of Helmet Wearing Rates Assessed During the MUARC Observational Surveys

Comparison of results from each of the MUARC surveys has enabled a detailed examination of ways in which helmet wearing has increased. In particular, data on helmet wearing was collected some 6 weeks prior to the introduction of the legislation in 1990. This can be compared with data collected from the 1991 survey which was conducted almost 12 months after the law commenced. Longer-term behaviour change was assessed by comparing the 1992 survey with the 1990 survey. Data from the 1987/88 MUARC survey has also been included in the following sections for completeness. It must be remembered, however, that this particular survey was carried out at a different time of year to the later surveys. Interpretations of trends based on these results must therefore be made with caution.

To determine variations in helmet wearing rates, data was collected on the number of helmet wearers as a proportion of the total sample; discrimination could also be made between sex, age, road class, location of bicycling and time of day. Such factors may affect the risk of a bicyclist being involved in an

Figure 7
Helmet wearing rates - 5-11 year olds
Melbourne Metropolitan area

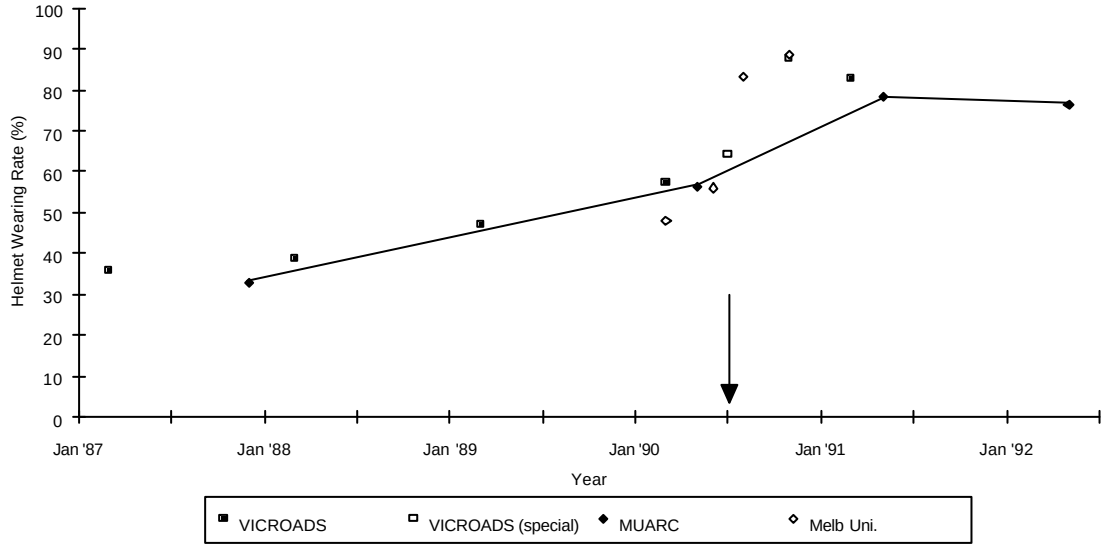


Figure 8
Helmet wearing rates - 12-17 year olds
Melbourne Metropolitan area

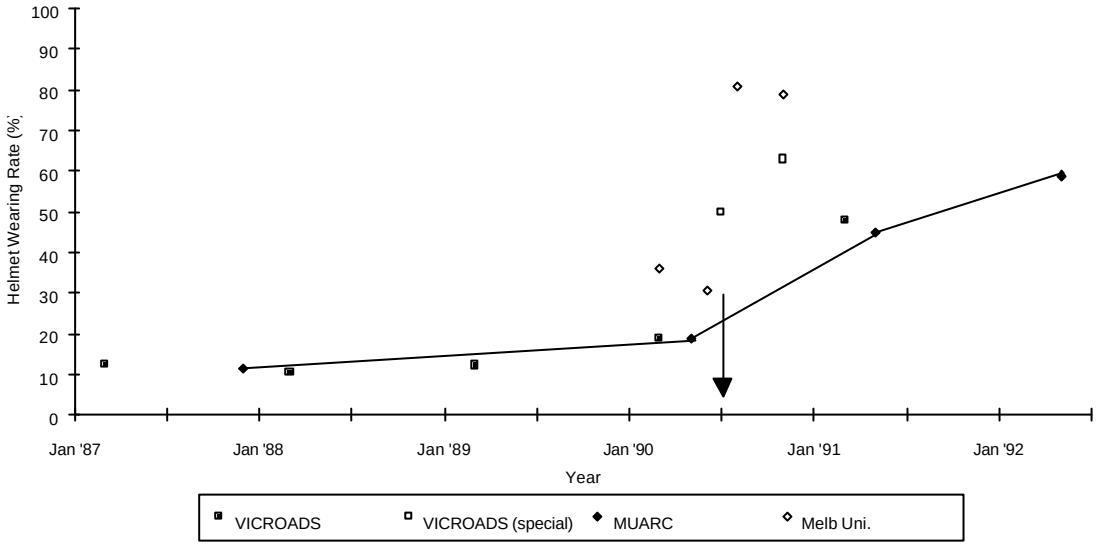
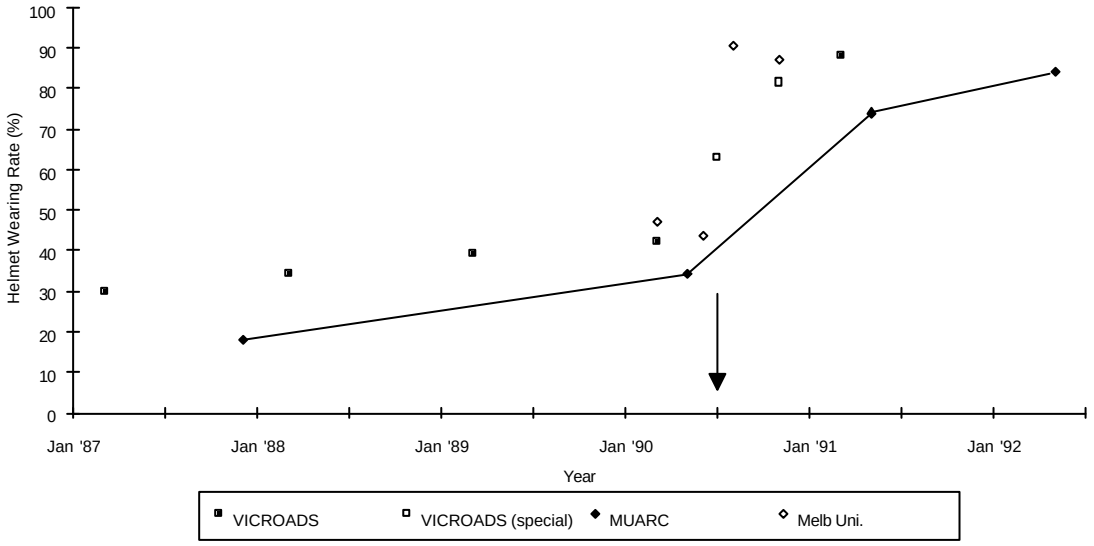


Figure 9
Helmet wearing rates - 18 years and over
Melbourne Metropolitan area



accident. Helmets provide suitable measures for secondary safety and so helmet wearing behaviour affects injury risk and severity if the bicyclist is involved in an accident.

The data in the subsequent sections on helmet wearing refer only to observations made in the 64 sites common to each MUARC survey.

5.2.2 Helmet Wearing Rates by Age Group

Figures 10-12 describe the trends in helmet wearing rates in each age group of bicyclists observed in the 64 sites during each survey. Each figure gives the proportion of the total number of bicyclists, within each age group, who were observed to be wearing helmets. The 95% confidence limits of this estimate are also indicated together with the number of bicyclists in each age group. As expected, helmet wearing rates pre-intervention were lower than those post-intervention in every age group. The fact that the rates were increasing prior to the law reflect the success of the activities described in Appendix 1.

In 5-11 year olds observed in the 64 sites, wearing rates rose from 65% in 1990 to 78% in 1991. The 95% confidence intervals shown on figure 10 indicate that this is a significant increase. In 1992, two years after the introduction of the law, the helmet wearing rate in this group was observed to be 77%. The overlapping confidence intervals indicate, however, that this was not a statistically significant decline in helmet wearing over the 1991 rate.

Helmet wearing rates in teenagers (age group 12-17 years) have typically been found to be less than those in primary school aged children and adults (Cameron et al, 1992). In the 1991 MUARC survey, the rate was 45% (rising from 21% in 1990). In 1992, helmet wearing in this group had increased further to 59%. Although this figure is still considerably lower than that in the other age groups (77% in primary school age children and 84% in adults) it represents an increase of 14% in helmet wearing over the 1991 figure. The rate in 1992 is significantly higher than the 1991 rate as shown by the non-overlapping confidence intervals.

Helmet wearing rates in adults have risen from 36% just prior to the law's introduction to 74% in 1991 and 84% in 1992. The confidence intervals indicated on figure 12 show that there has been a significant increase since 1991. For each of the pre-intervention surveys, as well as for the 1991 survey, helmet wearing rates in children aged 5-11 exceeded those in all other age groups. In 1992, for the first time since 1985, helmet wearing rates are highest in the adults (compare figures 10-12).

Table 5: Comparison of helmet wearing rates pre- and post- law implementation

Age-group (years)	Ratio of 1991 to 1990 rate	Ratio of 1992 to 1990 rate
5 to 11	1.2	1.2
12 to 17	2.2	2.9
18+	2.1	2.4

Table 5 indicates that, on a proportionate basis, the helmet wearing law has had its greatest effect on children aged 12 to 17 years of age. One year after introduction of the law, helmet wearing in this group had more than doubled. By 1992 it had almost tripled. The magnitude of this difference is a reflection of two major factors:

a) the low level of helmet wearing to begin with in 12-17 year olds; and
b) the influence of mandatory wearing laws on this age group.

However, their helmet wearing rates are still well below those in other age groups, suggesting that continued interventions need to be specifically targeted to this age group.

5.2.3 Age Group and Sex

Tables 6 and 7 reveal that there have been significant increases in helmet wearing rates for both females and males in the 64 sites. The largest rise in both surveys has been for teenage males. In 1990 and 1991, the female adult group had higher wearing rates than their male counterparts; this did not continue to be the case in 1992. Rates in teenagers were higher in females than in males in 1990 but post-intervention there was little or no sex difference. In 5 to 11 year old males, rates rose in 1991 but dropped slightly in 1992. In female children, rates have continued to rise since 1990. It should be noted that males represent between 78% and 89% of all bicyclists within each age group. Therefore programs which achieve increases in male helmet wearing rates will have larger injury reduction benefits.

Figure 10
Helmet wearing rates in 5-11 year olds

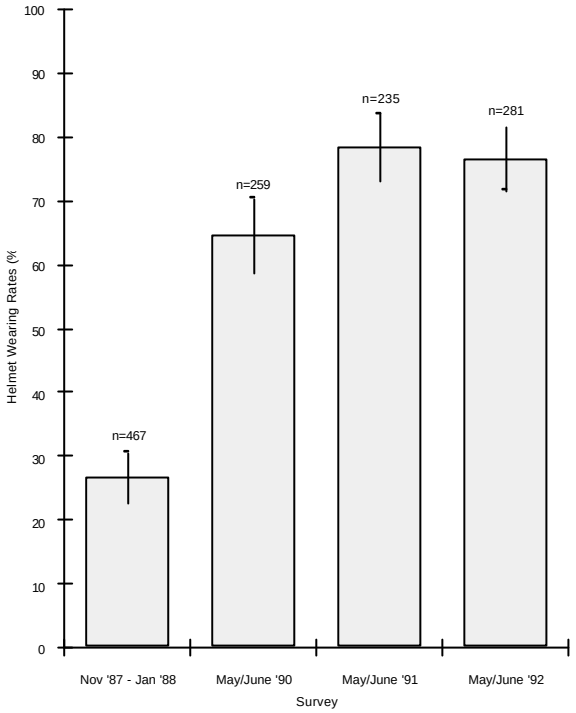


Figure 11
Helmet wearing rates in 12-17 year olds

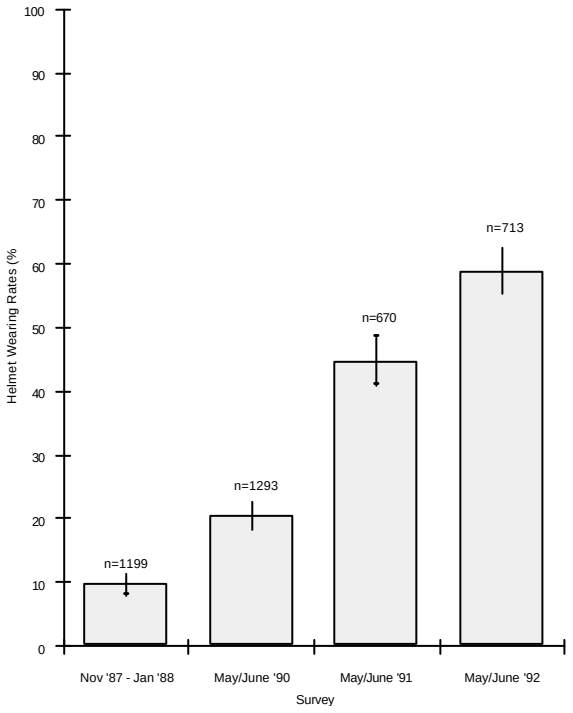


Figure 12
Helmet wearing rates in adults

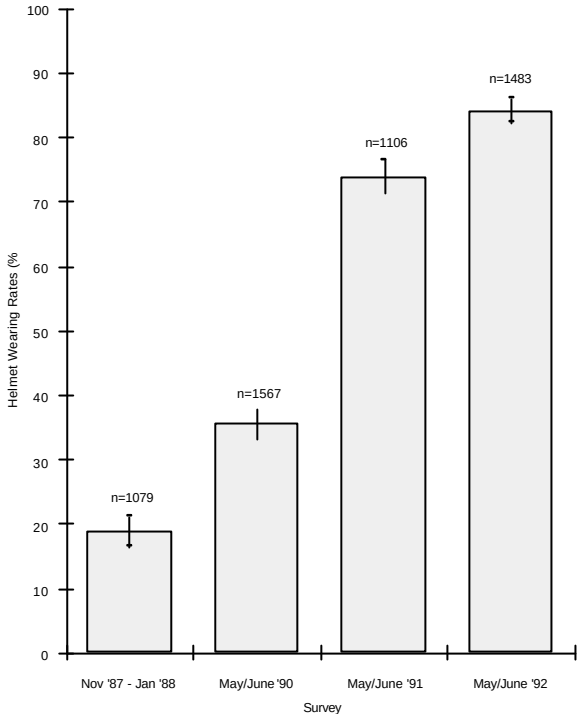


Table 6: Post-law increases in helmet wearing rates in males

Age-group (years)	1990 rate	1991 rate	Ratio of 1991 to 1990 rate	1992 rate	Ratio of 1992 to 1990 rate
5 to 11	65%	79%	1.2	74%	1.1
12 to 17	19%	45%	2.4	59%	3.2
18+	35%	73%	2.1	85%	2.5

Table 7: Post-law increases in helmet wearing rates in females

Age-group (years)	1990 rate	1991 rate	Ratio of 1991 to 1990 rate	1992 rate	Ratio of 1992 to 1990 rate
5 to 11	64%	76%	1.2	87%	1.4
12 to 17	31%	45%	1.5	58%	1.9
18+	41%	80%	1.9	77%	1.9

5.2.4 Age Group and Road Class

Figures 13 and 14 show the relationship between helmet wearing and road class in the different age groups. Prior to the introduction of the mandatory law, helmet wearing rates were higher on arterial roads than on local roads for all age groups. This pattern continued post-law in teenagers and adults. However, the relationship reversed for the 5-11 year old age group which, in 1992, had a wearing rate of 81% on local roads but a rate of only 69% in arterial zones. This shift is of some concern because the arterial road environment presents higher risks of accident involvement and head protection is essential to reduce the severity of head injury in the case of an accident.

Table 8: Changes in helmet wearing rates in arterial and non-arterial zones in 1991 and 1992, compared to 1990. (Numbers in the table are the ratios of the post-intervention rates to the 1990 rates)

	1991		1992	
Age-group (years)	**Arterial**	**Non-arterial**	**Arterial**	**Non-arterial**
5-11	1.1	1.3	1.1	1.2
12-17	2.3	2.0	3.2	2.5
18+	1.8	4.8	2.0	5.0

Table 8 indicates the relative increase in helmet wearing post-intervention compared to rates observed in 1990. In children and adults, the increase has been greater for non-arterial roads than in arterial zones; in teenagers, arterial helmet wearing rates rose more than non-arterial rates. The teenage group has shown large improvements in helmet wearing in both the arterial road environments (320% increase by 1992) and the non-arterial road environment (250% by 1992). Adults displayed a doubling of helmet wearing in arterial zones by 1992 and had achieved an even higher increase in non-arterial zones (500%).

5.2.5 Age Group and Location of Bicycling

In the 1990 survey of child bicycling, although helmet wearing was also recorded for adults, no note was made of where such bicyclists were riding. For this reason, adults in 1990 are excluded from the location specific analyses.

Figures 15 and 16 indicate differences in helmet wearing rates for road bicycling compared to footpath bicycling. For all age groups, except 12-17 year olds in 1990, rates were higher in road than in footpath bicyclists. This was particularly so for adults amongst whom, in 1992, 89% wore helmets when riding on the road but only 57% wore them when riding on the footpath.

Tables 9 and 10 show the change in helmet wearing rates amongst footpath and road bicyclists separately.

Figure 13
Helmet wearing rates in bicyclists observed in arterial zones

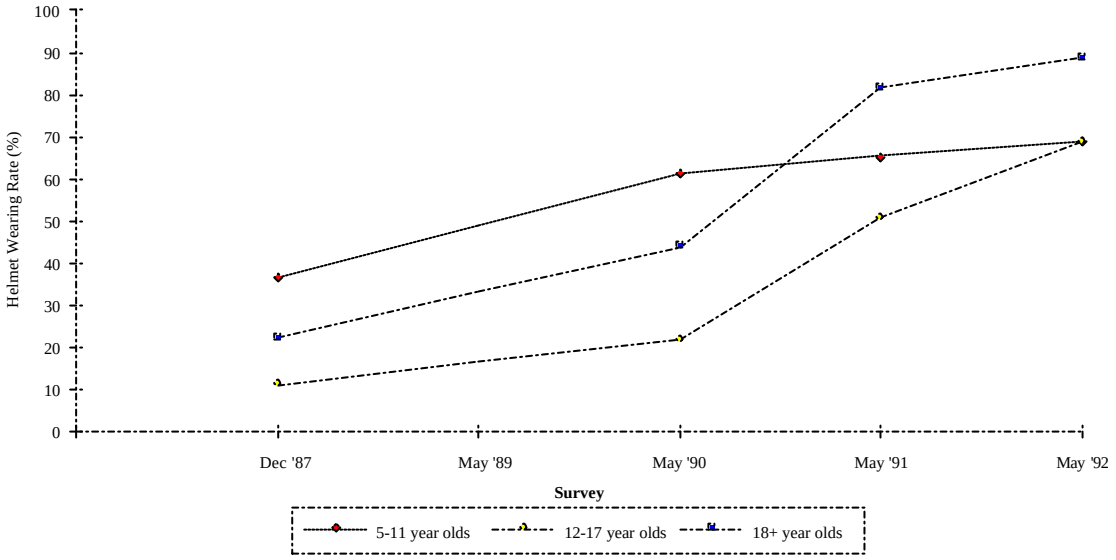


Figure 14
Helmet wearing rates in bicyclists observed in non-arterial zones

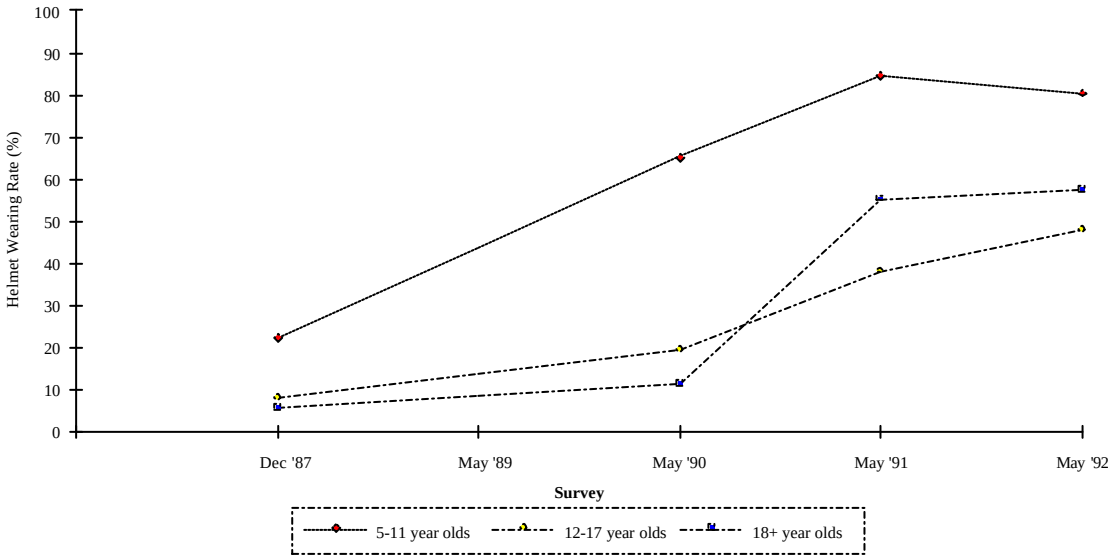


Figure 15
Helmet wearing rates amongst footpath bicyclists
(not available for adults in 1990)

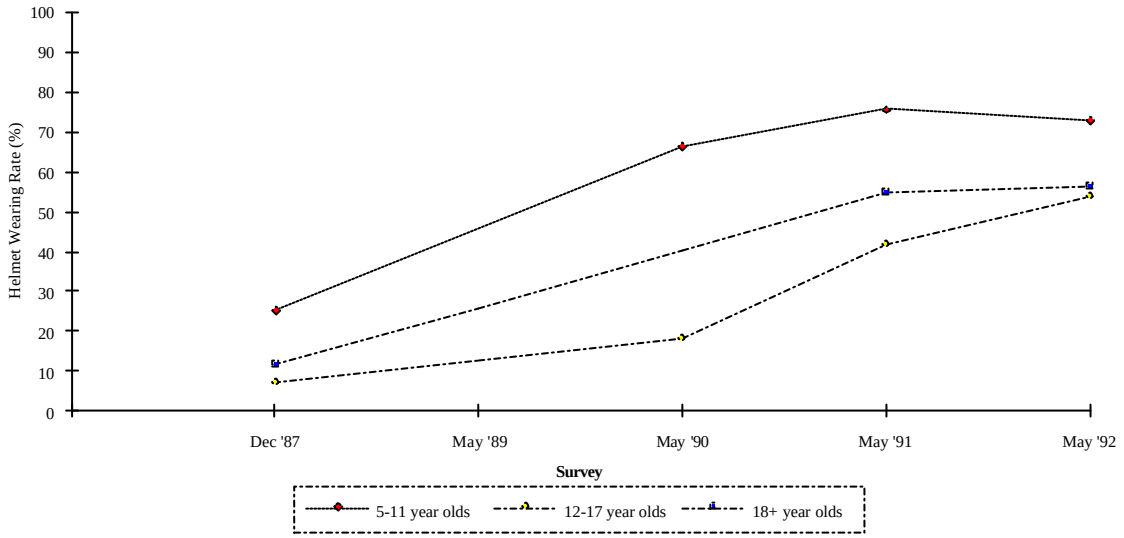


Figure 16
Helmet wearing rates amongst road bicyclists
(not available for adults in 1990)

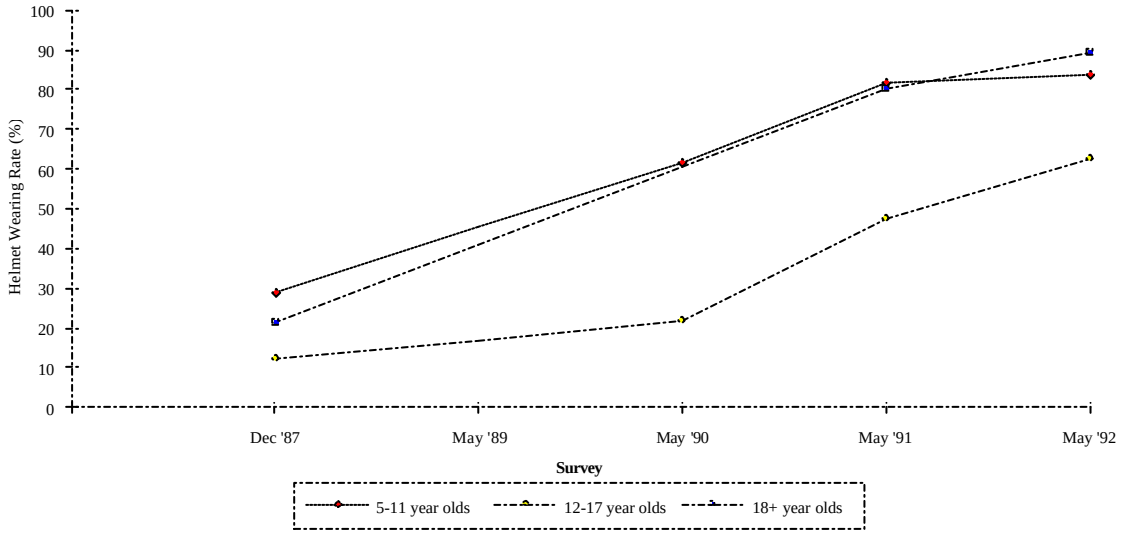


Table 9: Changes in helmet wearing rates amongst footpath bicyclists

Age-group (years)	Pre-law rate	1991 rate	Ratio of the 1991 and pre-law rates	1992 rate	Ratio of the 1992 and pre-law rates
5-11	66% (1990)	76%	1.1	73%	1.1
12-17	18% (1990)	42%	2.3	54%	3.0
18+	12% (1987/88)	55%	4.6	57%	4.8

Amongst both types of bicyclists, helmet wearing rates have increased post introduction of the law. For 5-11 year olds, this increase was greatest for road bicyclists (a 40% increase in 1992 over 1990, as opposed to a 10% increase for footpath bicyclists). Teenage bicyclists increased their helmet wearing to a similar extent for both footpath and road bicycling. Helmet wearing in adult footpath bicyclists increased more than in their road bicycling peers.

Table 10: Changes in helmet wearing rates amongst road bicyclists

Age-group (years)	Pre-law rate	1991 rate	Ratio of the 1991 and pre-law rates	1992 rate	Ratio of the 1992 and pre-law rates
5-11	62% (1990)	82%	1.3	84%	1.4
12-17	22% (1990)	48%	2.2	63%	2.9
18+	21% (1987/88)	80%	3.8	89%	4.2

5.2.6 Age Group, Location of Bicycling and Road Class

Helmet wearing rates for bicyclists engaged in road or footpath bicycling varied according to road class (Appendix 7). The figures in Appendix 7 indicate that helmet wearing rates amongst child footpath bicyclists were higher in non-arterial areas than in the arterial road environment. In 1990 this was also the case for adults and teenagers. In 1991 and 1992, however, the converse was true. In contrast to the footpath bicyclists, helmet wearing rates were higher in road bicyclists travelling in arterial road environments than in non-arterial sites (Appendix 7, figures 3 and 4)

When comparing footpath and road bicyclists in arterial zones (Appendix 7, figures 1 and 3) helmet wearing rates were higher for bicyclists on the road rather than on the footpath. This behaviour is consistent with the higher risk of accident involvement associated with riding on the road in heavily trafficked thoroughfares. When bicycling on local roads, adults in 1992 exhibited a higher wearing rate on the road than on the footpath (61% versus 43%). Eighty-three per cent of child bicyclists wore helmets in 1992 on the road compared to 78% of footpath bicyclists. Teenagers had a somewhat similar rate when riding on the footpath (51%) or on the road (47%).

5.2.7 Helmet Wearing Rates by Age Group and Time of Week

Figures 17-20 show the variation in helmet wearing rates according to age group and the time of the week during which the bicycling occurred. Within each time of the week grouping, helmet wearing rates have increased across the four surveys. The exception to this trend are child rates in 1992 compared to 1991 on weekday mornings and weekend afternoons. The increase in rates from pre to post law was greatest on weekend mornings for children (the 1992 rate is 1.7 times that of the 1990 rate). In teenagers, the greatest improvement (a 3.5 fold increase in 1992 over 1990) was on weekday mornings (possibly on the way to school). Adults had the best improvement (3.7 times) on weekend afternoons (ie. during recreational bicycling periods).

Figure 17
Helmet wearing rates in bicyclists observed on weekday mornings

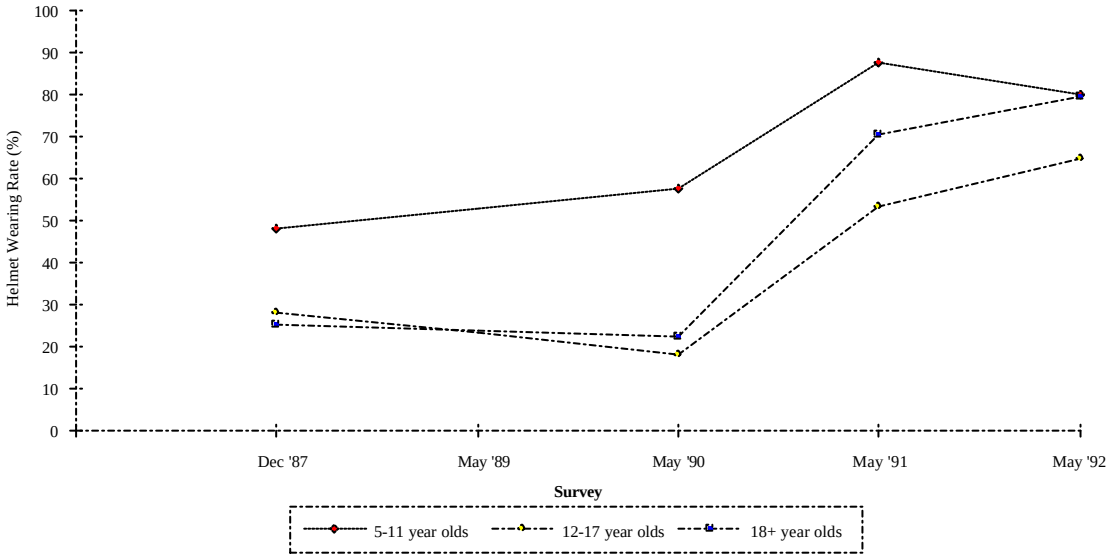


Figure 18
Helmet wearing rates in bicyclists observed on weekday afternoons

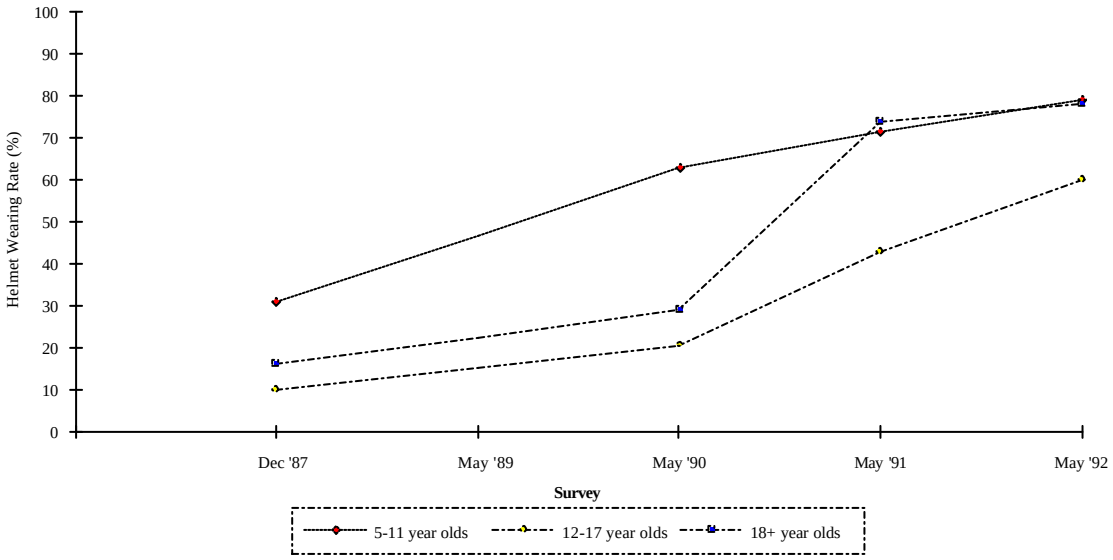


Figure 19
Helmet wearing rates in bicyclists observed on weekend mornings

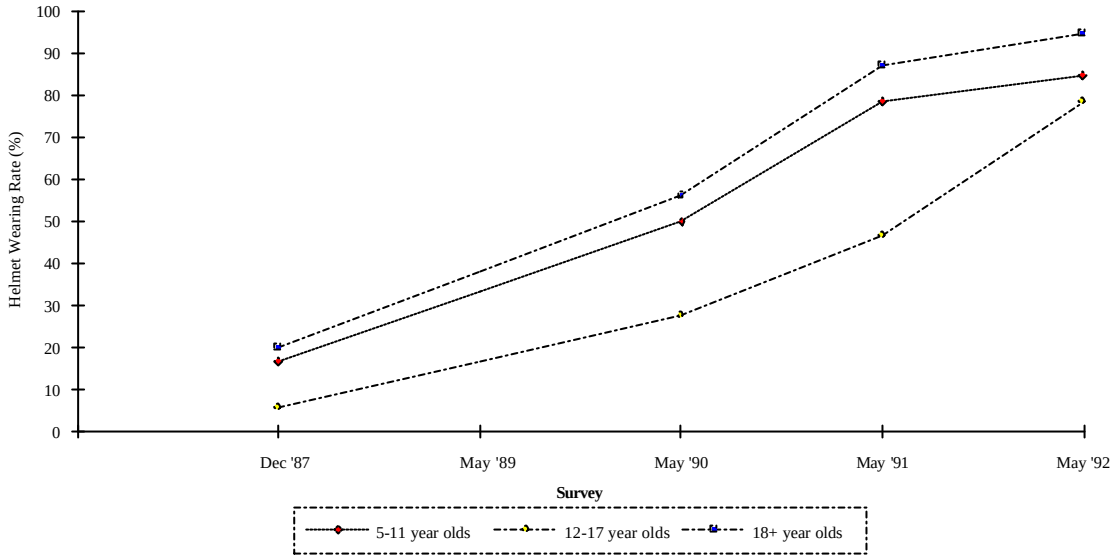
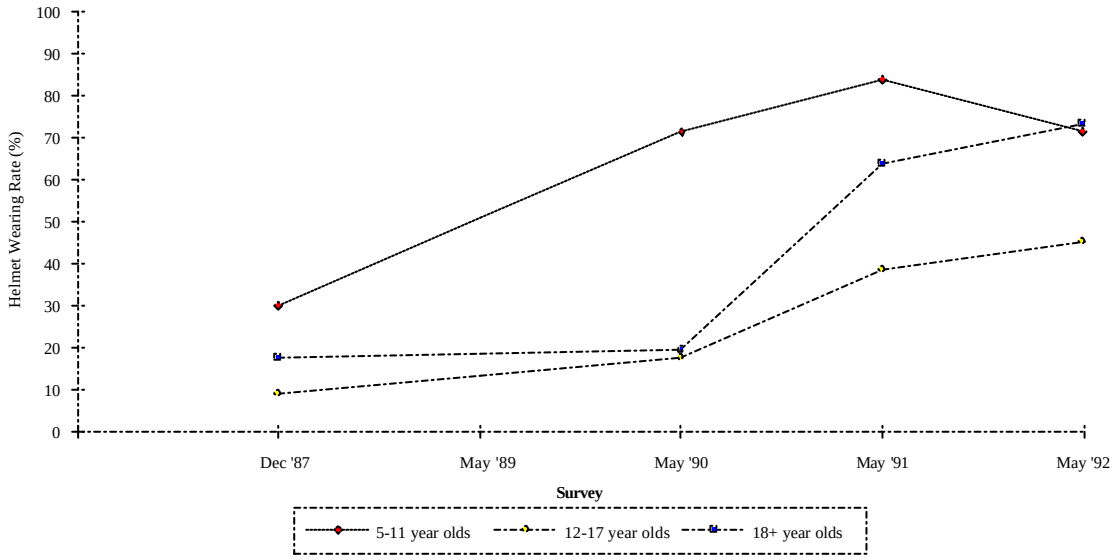


Figure 20
Helmet wearing rates in bicyclists observed in weekend afternoons



On weekday mornings, the wearing rates are highest in children (presumably whilst on the way to school). Inexplicably, the time when helmet wearing is at its peak for adults is during weekend mornings. Lowest wearing rates for both teenagers and adults occur during the weekend afternoons. In 1991, lowest rates for children were on weekday afternoons (presumably on the way home from school or engaged in recreational bicycling). In 1992, this changed to weekend afternoon bicycling, a time of recreational bicycling.

5.3 HELMET OWNERSHIP RATES

In 1991 and 1992, in addition to helmet wearing status, behaviours associated with the wearing of helmets were also recorded. In particular, when bicyclists were not wearing helmets, the trained observers recorded whether or not they were carrying a helmet on their bike. By combining this data

with that on helmet wearers, helmet ownership rates can be defined as the proportion of bicyclists wearing or carrying a helmet.

Figures 21 and 22 display helmet ownership rates in 1991 and 1992, respectively. The whole of the bar shown in these figures indicates the helmet ownership rates; the 95% confidence interval also indicated corresponds to this rate. Each bar has shaded components to indicate the relative contributions due to bicyclists wearing or carrying helmets.

In 1991, 82% of children, 57% of teenagers and 76% of adults owned helmets. Amongst the helmet owners, 96% of children and 98% of adults were wearing them. Of some concern in 1991 was the fact that nearly 20% of teenagers were carrying their helmets rather than wearing them.

In 1992, 78% of children, 65% of teenagers and 86% of adults owned helmets. Apart from the 5 to 11 year olds, this was an increase in ownership over the 1991 rates. Amongst those owning helmets, 99%

Figure 21
Helmet "ownership" rates in 1991
(Ownership rates are the proportion of bicyclists wearing or carrying a helmet)

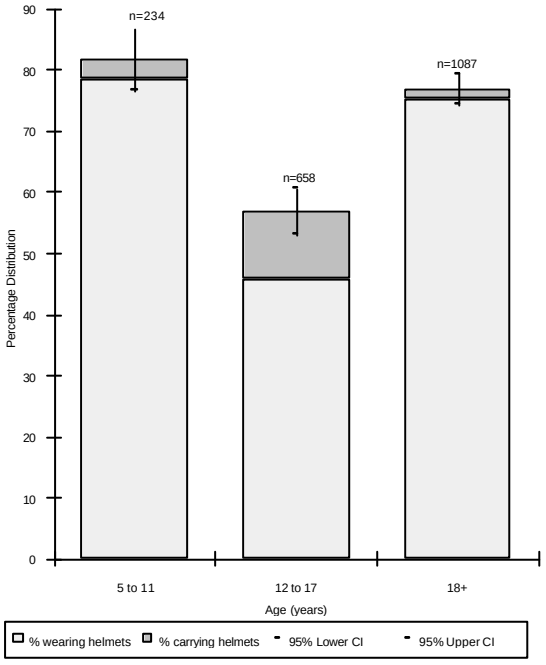
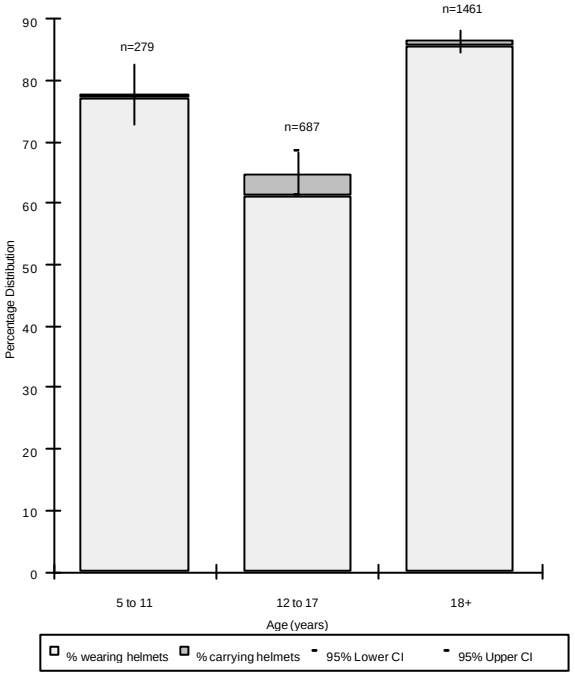


Figure 22
Helmet "ownership" rates in 1992



of both children and adults were wearing them. The proportion of 12 to 17 year old helmet owners who wore their helmets in 1992 was 94%, a significant increase over the proportion in 1991, though still lower than in the other two age groups.

These findings provide a partial explanation for the changes in helmet wearing rates observed between 1991 and 1992 (Section 5.2.2). Whilst the proportion of child helmet owners wearing their helmets has increased, there were fewer owners in 1992. This could explain the (non-significant) decrease in overall helmet wearing rates in this age group. On the other hand, helmet ownership has increased in adults and teenagers and this could account for some of the increase in overall helmet wearing rates in this group. In teenagers, in particular, the increase in the proportion of helmet owners wearing their helmets has been quite large (80% in 1991 versus 94% in 1992). It is obvious that this change must explain part of the increase in helmet wearing rates in teenagers.

5.4 PROPORTION OF WORN HELMETS THAT WERE SECURED

In 1991 and 1992, data was collected on the correct wearing of helmets in terms of whether the chin strap was done up or not. This section describes observations relating to the securing of helmets by those bicyclists who were wearing helmets.

5.4.1 Age Group and Sex Distributions

Table 11 describes the percent of helmet wearers with their chin strap done up in 1991 and 1992, respectively. From 1991 to 1992, this proportion remained the same or increased in female adults and teenagers. In 1992, there was only one female, out of a total of 44 children, who did not fasten her helmet. Rates exceeded 98% in each age-group of helmet wearers during both surveys.

The proportion of males correctly wearing their helmets exceeded 94%. Amongst children, 2 males did not wear their helmets done up during both surveys. In all other age groups, there had been an increase in the proportion of helmets being worn correctly.

Table 11: Proportion of male and female helmet wearers with their chin straps done up

	Females		Males	
Age-group (years)	1991	1992	1991	1992
5-11	100%	98%	99%	99%
12-17	100%	100%	94%	97%
18+	99%	99%	99%	99%

5.4.2 Age Group and Road Class

Table 12 shows the proportion of bicyclists correctly wearing their helmets according to road class in 1991 and 1992, respectively.

Table 12: Proportion of bicyclists correctly wearing their helmets according to road class in 1991 and 1992

	Arterial Zones		Non-arterial zones	
Age-group (years)	1991	1992	1991	1992
5-11	100%	100%	99%	98%
12-17	97%	97%	92%	98%
18+	99%	99%	97%	98%

For all age groups, (except teenagers in 1992), the proportion of helmets that were done up whilst bicyclists were riding in arterial zones was higher than the corresponding proportion on local roads.

In 1991, the teenage group was less likely than any other group to secure their helmets when bicycling on non-arterial roads. In 1992, the lowest rates were for adults on non-arterial roads. Teenagers were also the least likely group to have secured helmets on arterial roads during both surveys.

5.4.3 Age Group and Location of Bicycling

Table 13 describes differences in the security of worn helmets in the two surveys for footpath and road bicyclists separately. With the exception of children, more helmets tended to be securely fastened on bicyclists travelling on the road than on the footpath.

Table 13: Proportion of bicyclists correctly wearing their helmets according to location of bicycling in 1991 and 1992

	Footpath		Road	
Age-group (years)	1991	1992	1991	1992
5-11	99%	99%	98%	97%
12-17	94%	97%	96%	98%
18+	96%	97%	99%	99%

5.5 TYPE OF HELMETS BEING WORN BY BICYCLISTS

An assessment of the protective performance of bicycle helmets maybe, in part, a reflection of the proportions of hard and soft-shell helmets being used. For this reason, data was also collected on the type of helmet being worn in 1991 and 1992 (ie. hard-shell or soft-shell). However, sometimes the observers had difficulty in discriminating between these two types. The existence of thin-shell helmets (coded as foam-only helmets for these surveys) exacerbated the problem. Because of these problems, the reader should treat the following results with caution.

5.5.1 Age and Sex Distribution

Figure 23 indicates the type of helmet worn by female bicyclists in 1991 and 1992. For each age group, the most popular choice of helmet was a hard-shell type though this preference declined with increasing age. There were more teenagers wearing hard-shell helmets in 1992 than in 1991 (77% versus 68%).

Generally, males preferred hard-shell rather than foam-only helmets (figure 24). In 1991, however, more adult males favoured soft-shell helmets rather than hard-shell ones. By 1992, this ratio had been reversed. Once again, the preference for hard-shell helmets decreased with advancing age.

Overall, the preference for hard-shell rather than soft-shell helmets was similar in both sexes.

Figure 23
Type of helmet worn by female bicyclists

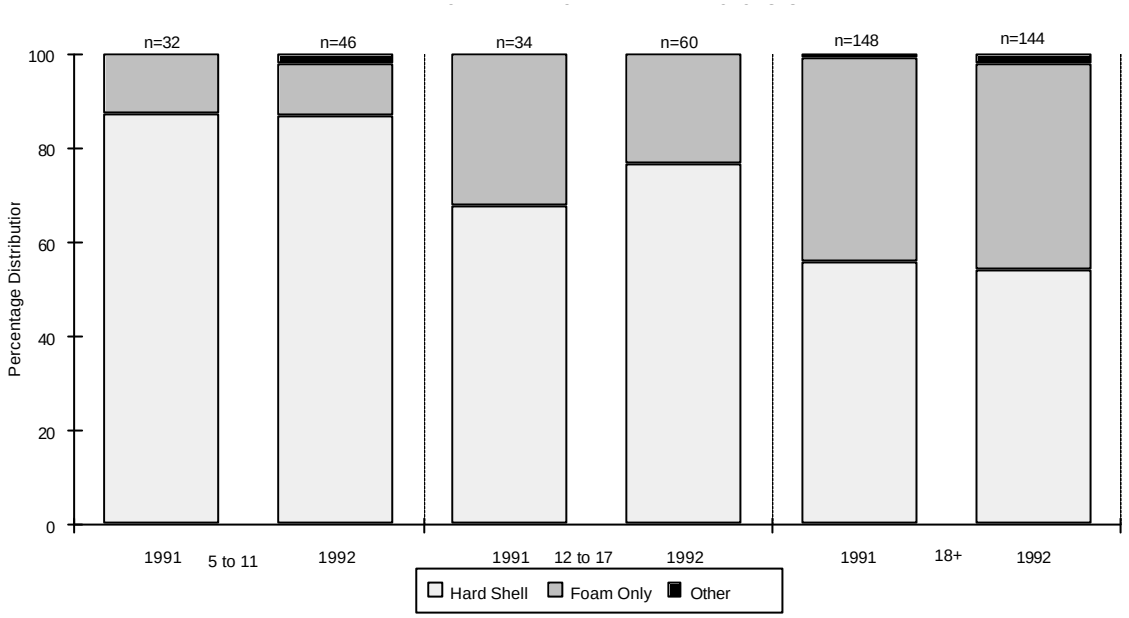
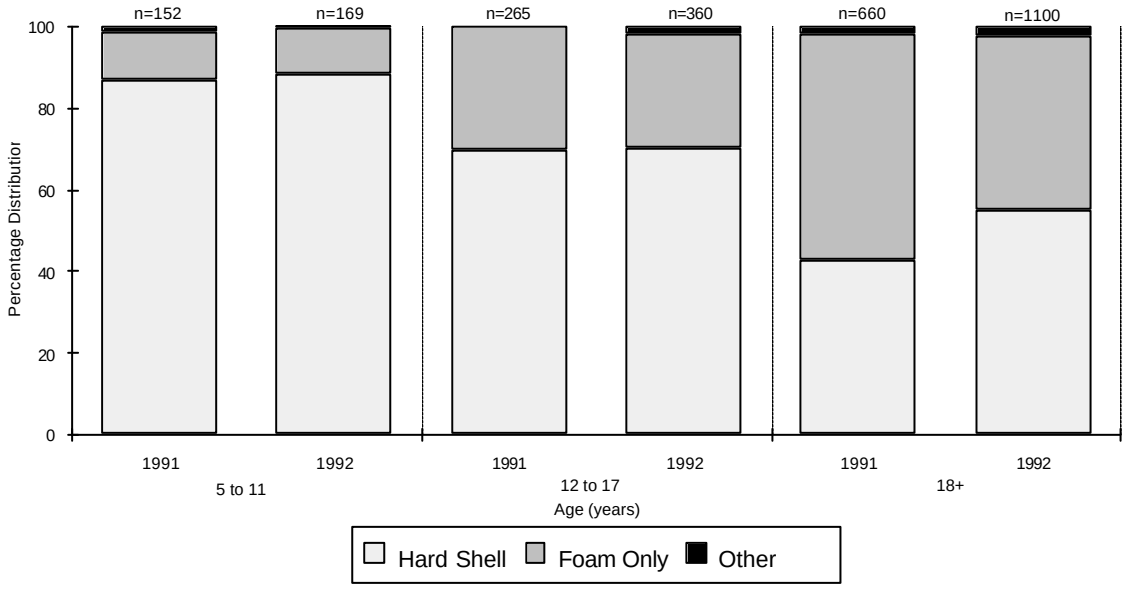


Figure 24
Type of helmet worn by male bicyclists



5.5.2 Age and Road Class

When the distribution of helmet types was examined according to road class, a greater preference for hard-shell helmets when bicycling on non-arterial roads rather than on arterial roads was evident (Table 14).

Table 14: Proportion of hard-shell helmets worn by bicyclists according to road class in 1991 and 1992

	Arterial zones		Non-arterial zones	
Age-group (years)	1991	1992	1991	1992
5-11	71%	88%	93%	88%
12-17	63%	66%	79%	78%
18+	42%	53%	58%	70%

5.5.3 Age and Location of Bicycling

Table 15 gives the percentage of hard-shell helmets amongst bicyclists observed on footpaths and roads. Amongst bicyclists of all ages, hard-shell helmets were worn less often by footpath bicyclists than by those riding on the road. In both locations, hard-shell helmets were worn more frequently by children than by both groups of older bicyclists. The proportion of teenagers wearing hard-shell helmets was greater than that for adults amongst footpath bicyclists but the converse was true for bicyclists who travelled on the road.

Table 15: Proportion of hard-shell helmets worn by bicyclists according to location of bicycling in 1991 and 1992

	Footpath		Road	
Age-group (years)	1991	1992	1991	1992
5-11	65%	67%	72%	69%
12-17	31%	40%	31%	43%
18+	55%	37%	34%	48%

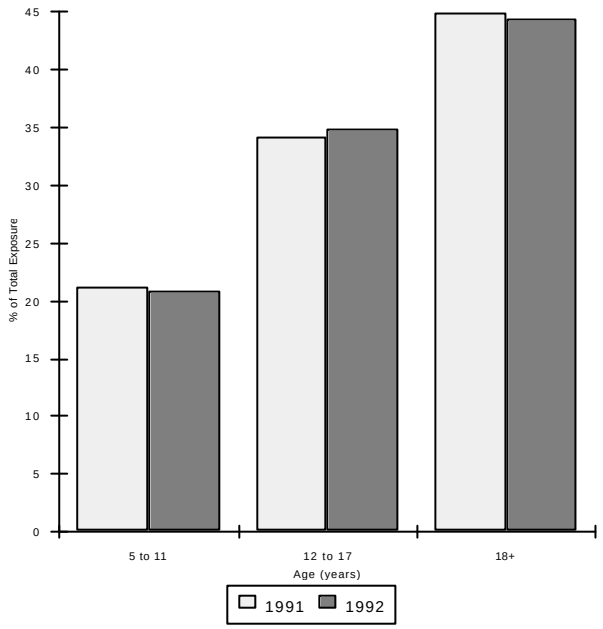
5.6 BICYCLE USE

To measure the changes in bicycle use since the introduction of the helmet wearing legislation, bicyclists have been categorised according to the factors which relate to bicyclist accident risk. Data has been analysed for bicycling activity according to the age of the bicyclist, the type of road class and the location of the bicycling. Bicycle use was measured in seconds and all figures express bicycling time in billions of seconds. The bicycle usage data represents an estimate of the total bicycling time in the Melbourne metropolitan area over a one week non-holiday period in each year for which it is computed.

5.6.1 The Profile of Bicyclist Exposure in 1991 and 1992

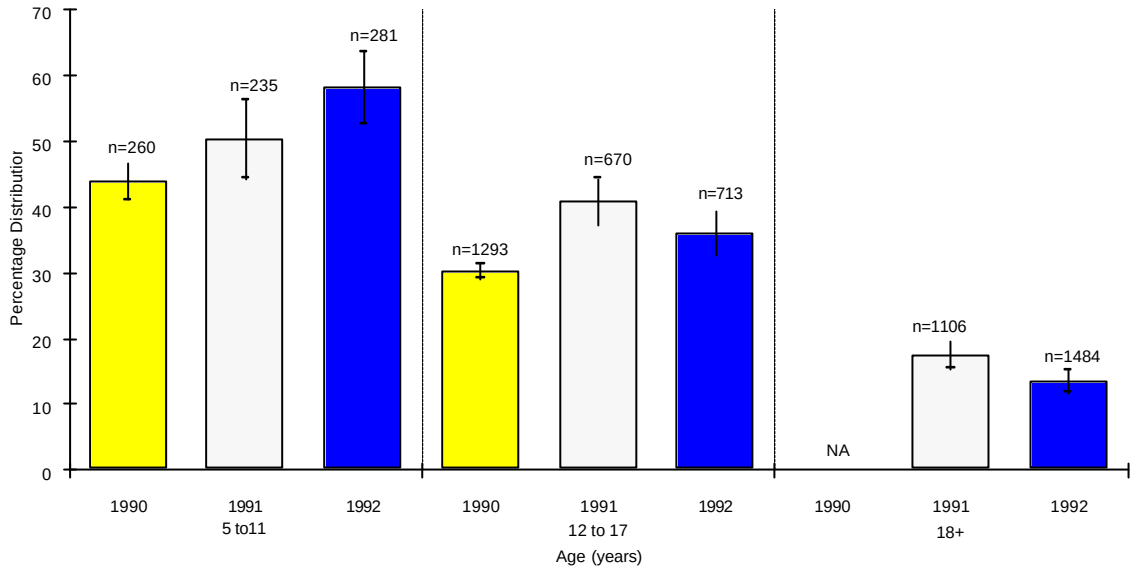
Figure 25 gives the distribution of total exposure (billions of seconds /week) in 1991 and 1992 according to age group. On average, adults accounted for 45% of the total estimated bicycle exposure; 35% of the total exposure was experienced by teenagers and 21% by children. The data for 1990 is not included in this figure because exposure was not measured in adults. However, total exposure in teenagers was 2.8 times that observed in children in 1990.

Figure 25
Distribution of exposure by age group



Since exposure was timed on the footpath and road separately, the proportion of total exposure occurring on the footpath (or road) can be calculated for each bicyclist. Amongst bicyclists observed in 1991 and 1992, the average proportion of their exposure that occurred on the footpath, rather than on the road, decreased considerably with age (figure 26). The 95% confidence intervals of this mean proportion of road exposure are also indicated. Over the period 1991-1992, adults decreased their average percent of total exposure on the footpaths from 18% to 14%. Teenagers also decreased their footpath exposure - an average of 41% of their total exposure on footpaths in 1991 versus 36% in 1992. Amongst children, however, the average proportion of total exposure occurring on the footpaths increased from 50% in 1991 to 58% in 1992. None of these changes, however, were statistically significant (all confidence intervals are overlapping).

Figure 26
Average percent of total exposure occuring on footpaths



Appendix 8 describes the complementary trends in the average proportion of exposure on roads in each age group for the two surveys.

The average proportion of exposure occurring on the footpath (rather than on the road) can be broken down further by sex and road class (Appendix 8). In females, average footpath exposure was higher in arterial zones than in non-arterial ones in all age groups, except children in 1990. This was particularly so during the post-law surveys during which footpath exposure in arterial zones was 2.2 times that in non-arterial zones in children and 3.1 times greater in teenagers. Average non-arterial footpath exposure was not very much different from that in arterial zones in adults (16% versus 18% in 1991, and 18% versus 17% in 1992). Since 1990, the average percent of total exposure occurring on the footpaths in arterial zones has increased in children and teenagers. The converse is true for non-arterial exposure.

A similar pattern was observed in males during the two surveys (Appendix 8). For each age group, except adult males in 1992, the average proportion of exposure occurring on the footpath was higher in non-arterial than arterial zones. The difference between arterial and non-arterial road exposures was more marked for 5-11 year males than for females of the same age. In 1991, non-arterial road exposure was 2.2 times that in non-arterial zones; in 1992, this increased to 2.4 times. In teenagers, the 1991 footpath exposure in arterial zones was 3.1 times that in non-arterial zones; in 1992 this same ratio was 2.5.

5.6.2 Trends in Total Bicycle Exposure in 64 sites

This analysis is based only on estimates of total exposure derived from observations in the 64 sites in common to each survey. Total bicycle use for all child and teenage bicyclists decreased by 33%, from 17.8 billion seconds per week in 1990 to 12.0 billion seconds per week in 1991. In 1992, total bicycle use by children and teenagers was estimated as 11.3 billion seconds per week; this represents a decline of 36% over the pre-law level.

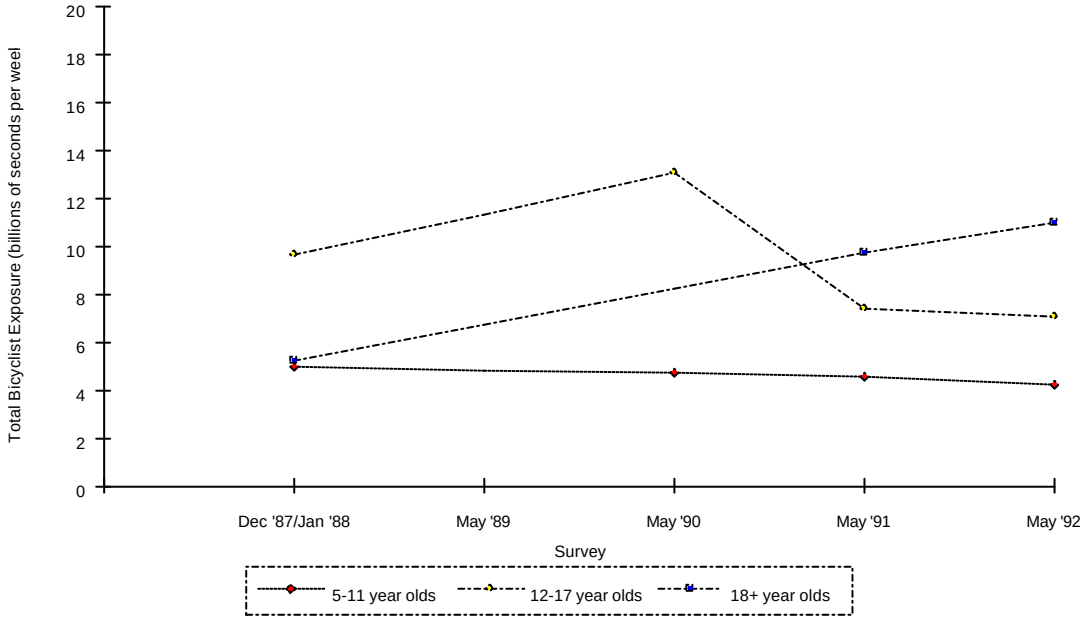
Comparison of the 1987/88, 1991 and 1992 surveys allows the change in bicycle use for all bicyclists aged 5 years and above in the 64 sites to be assessed. It should be remembered that this comparison

was made at different times of the year and almost 3.5 years apart and therefore is considered unreliable. Total use rose by 9% from 19.9 billion seconds per week in 1987/88 to 21.7 billion seconds per week in 1991 and further increased to 22.4 billion seconds per week in 1992, representing a 12% increase over the 1987/88 figure and a 3% increase over the 1991 estimate. This increase can be largely attributed to an increase in bicycle use by adults as described in the next section.

5.6.3 Age-specific Trends in Total Bicycle Exposure in 64 Sites

The previous section indicated that overall total bicycle exposure had decreased during the survey periods but that adults had increased their exposure during 1991 to 1992. Trends in estimated bicycle use (billions of seconds per week) are shown in figure 27 for each age group separately. In the 64 sites common to each survey, total bicycle use in children decreased by 3% from 4.7 billion seconds per week in 1990 to 4.6 billion seconds per week in 1991. In 1992, child exposure in these 64 sites (4.2 billion seconds per week) was 11% less than that in 1990. Teenage exposure decreased by 44% from 13.1 billion seconds per week in 1990 to 7.4 billion seconds per week in 1991. After 1991, there was a further decrease to 7.1 billion seconds per week, or a 46% decrease from the pre-law level.

Figure 27
Estimated bicycle use in Melbourne according to age group

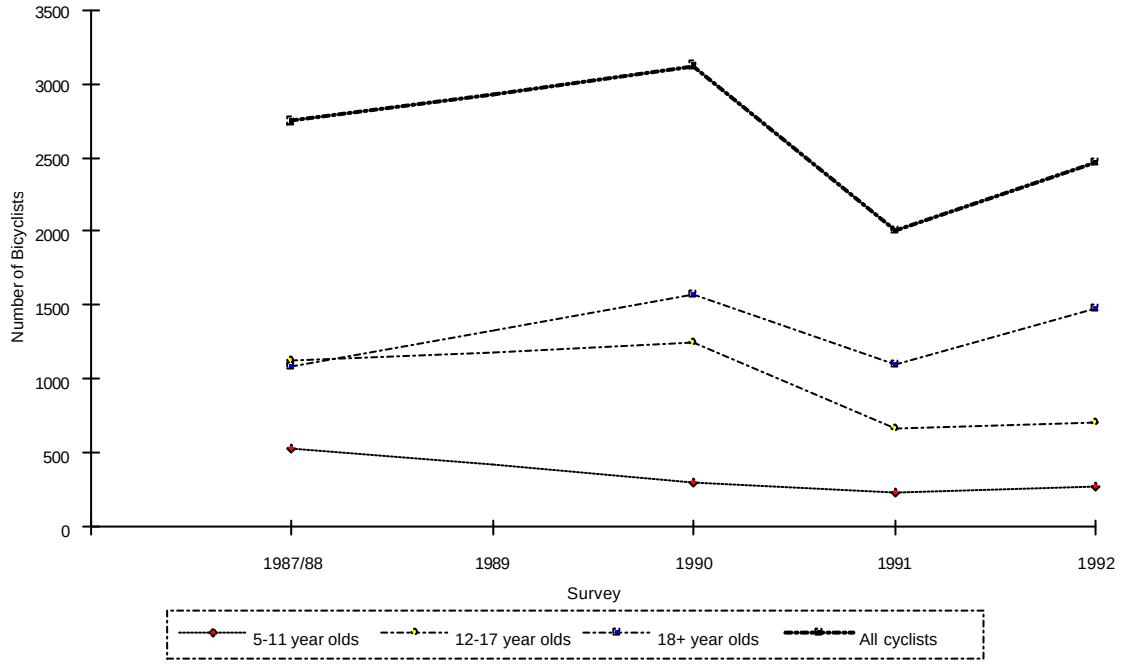


Amongst adults, there has been a marked increase in bicycle usage over the period covered by the MUARC surveys. Compared to the estimate of exposure from the 64 sites in 1987/88, there was a 86% increase in usage by 1991. This further increased in 1992 to a level more than double that in the first survey.

5.6.4 Numbers of Bicyclists Observed During Each of the MUARC Surveys

The number of bicyclists observed in the 64 sites in common to each of the MUARC surveys is shown in figure 28. In the total group of bicyclists, the number of bicyclists fell by 36% from 3121 in 1990 to 2011 in 1991. By 1992, the number of bicyclists had increased to 2472 which represented an increase of 23% over the 1991 level and a decrease of 21% from the pre-law level.

Figure 28
Numbers of bicyclists observed during each of the MUARC surveys



In each age-group, a drop in the number of bicyclists was observed during the first year after the law (a 24% drop in children, 46% in teenagers and a 29% drop in adults). The decrease in children was a continuation of the decline already apparent in this group prior to the law (figure 28).

During the period 1991-1992, there has been an increase in the number of bicyclists of all ages. This was most marked for adults where numbers increased from 1106 to 1484 in 1992 (a 34% increase). Numbers increased from 1991 to 1992 by 6% in teenagers and by 20% in children. As a result of these increases, the number of adult and child bicyclists was not much smaller than the pre-law numbers (a 9% drop in children, 5% in adults). However, the number of teenage bicyclists remained considerably less than the pre-law level (a 43% decrease).

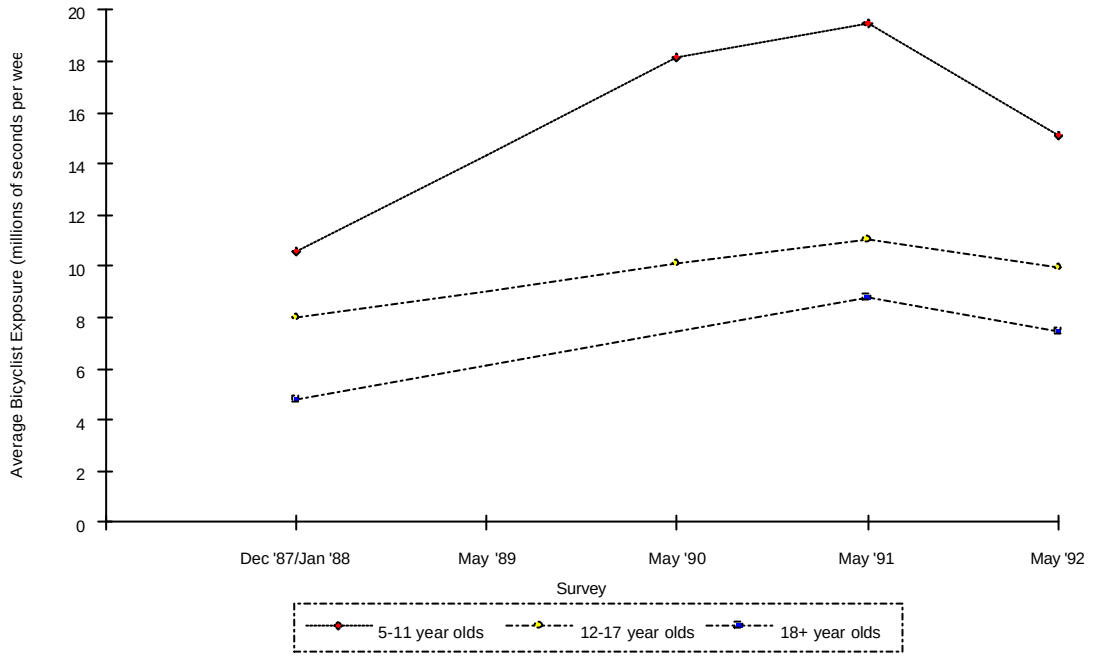
5.6.5 Trends in the Average Amount of Bicycling Time per Bicyclist

Section 5.6.3 described a decline in total bicycle usage in the 64 sites across the survey period whereas the results of the previous section describe trends in the numbers bicyclists observed. An explanation for the apparent contradiction in these two sections is given in figure 29.

In all surveys up to, and including, the 1991 survey (ie in both pre- and post- intervention assessments), the average exposure per bicyclist increased in all age groups. This increase was most marked in children over the period 1987/88 to 1990. Average exposure per bicyclist declined, however, between 1991 and 1992 despite there being more bicyclists in each age group (figure 29).

Although the number of children observed was less than in any other age group, the average amount of time spent on the road was highest for this group during each survey. Adults, the most numerous group, spent the least amount of time bicycling, on average. This may just reflect the fact that, per unit distance, adults can travel at a greater speed.

Figure 29
Estimated average bicycle exposure in Melbourne according to age group



Figures 28 and 29, together, suggest that the decline from 1990 to 1991 for each age group was due to decreases both in average bicycling time and fewer bicyclists. However, the decline in bicycle exposure between 1991 and 1992 in children and teenagers was due to a decreasing of the average time spent bicycling rather than to fewer bicyclists of this age riding their bikes. Although average exposure per bicyclist also decreased in adults, the increase in the number observed in 1992 over 1991 accounts for the increase in total bicycle exposure in this group.

5.6.6 Trends in Bicycle Exposure According to Location of Bicycling and Road Class

Figure 30 describes trends in bicycle use on footpaths in each age group across all surveys. In 1987/88 and 1990 teenagers had a higher total exposure on footpaths than all other age groups. By 1992, children aged 5-11 years had higher exposures on the footpath. Over the study period, there has been a slight general increase in footpath exposure in children but a marked decrease in teenagers. In 1992 child exposure was 1.1 times that in 1990 and teenage exposure was almost half (47%) of its pre-law level. Comparison of the exposure in adult footpath bicyclists in 1992 with that in 1988 showed a 53% increase.

Total exposure on the roads (rather than on the footpaths) was highest in teenagers in 1987/88 and 1990. In 1991 and 1992, adults had higher total road exposures (figure 31). For both teenagers and children, road exposure has decreased since the helmet wearing law was introduced (a 23% decline by 1992 in children and by 42% in teenagers). In contrast, adult exposure on the road was 2.3 times that of the 1987/88 level in 1992. Furthermore, total road exposure increased by 20% in adults between 1991 and 1992.

Appendix 9 describes exposure trends in footpath and road bicyclists in arterial and non-arterial sites separately. Since the introduction of the helmet wearing law, total bicycle exposure on the footpaths has increased in all age groups in arterial zones. The opposite has occurred in non-arterial zones. Similar trends were apparent for exposure on roads.

Figure 30
Estimated total bicycle exposure on footpaths in Melbourne according to age group (not available for adults in 1990)

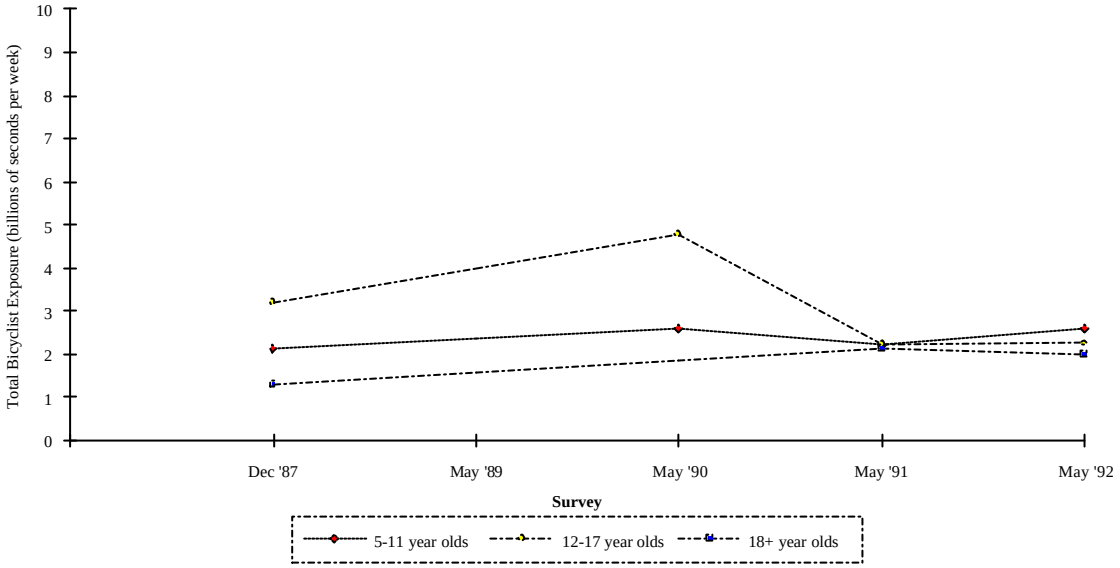


Figure 31
Estimated total bicycle exposure on roads in Melbourne according to age group (not available for adults in 1990)

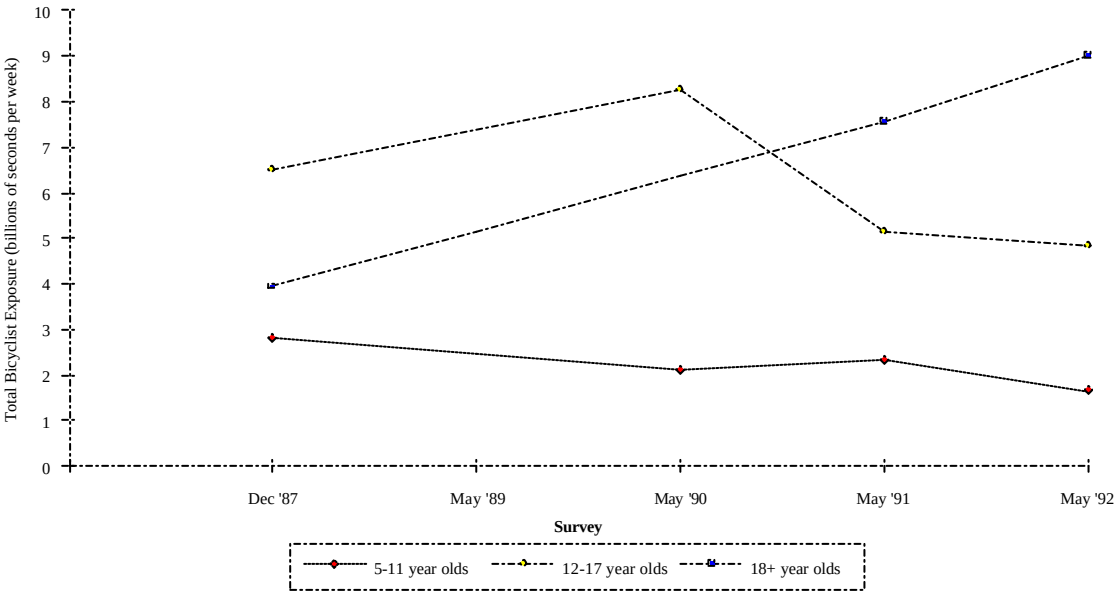
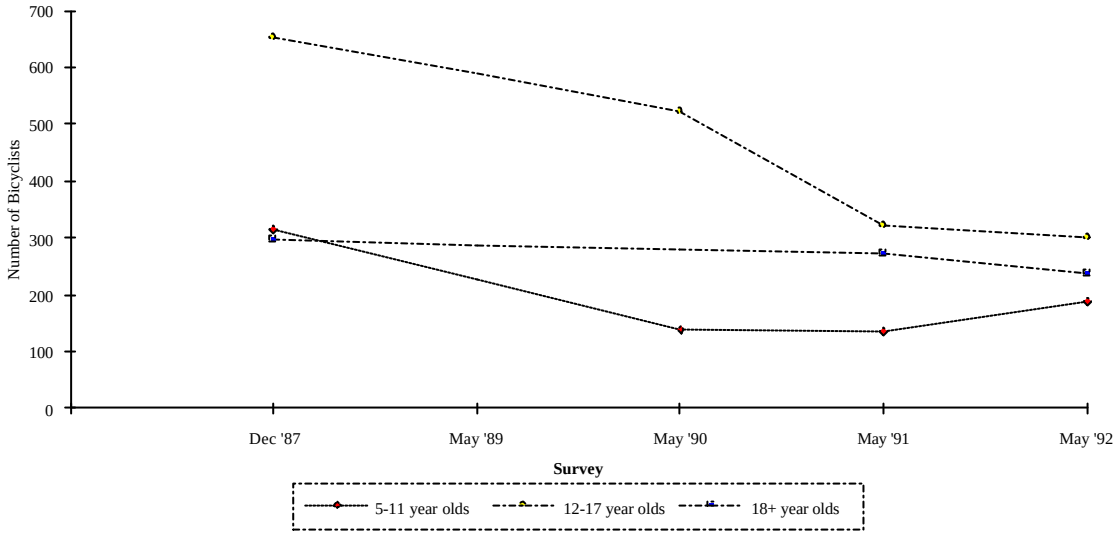
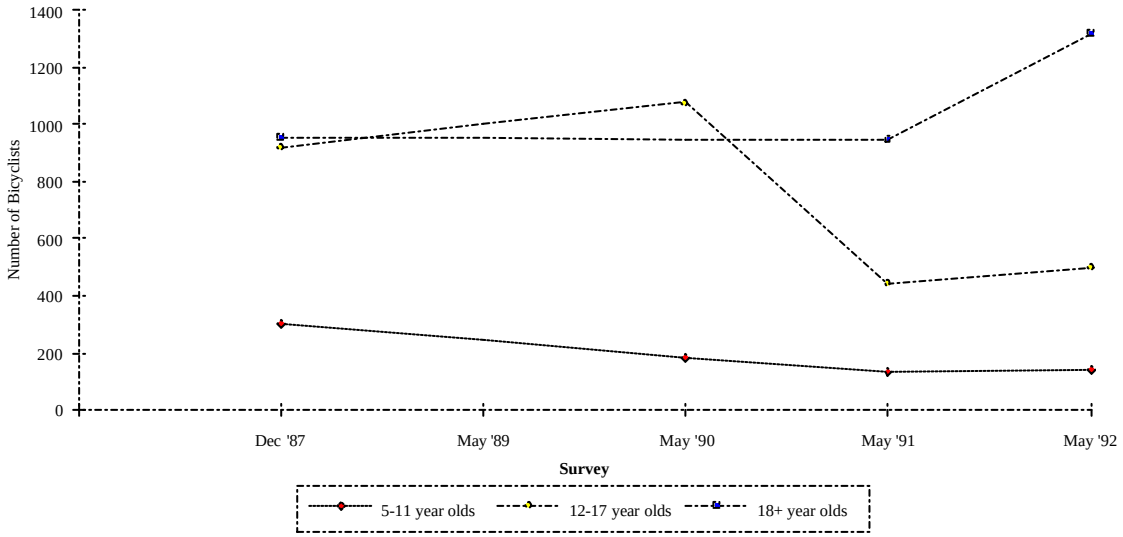


Figure 32
Number of bicyclists observed on footpaths according to age group (not available for adults in 1990)



These trends are also reflected in changes in the trends in the numbers of bicyclists observed on the footpath and road during each of the surveys (figures 32 and 33). The number of adult bicyclists on the footpaths decreased over 1991-1992 but there was a large increase in the numbers of bicyclists riding on the road (rather than on the footpath).

Figure 33
Number of bicyclists observed on roads according to age group (not available for adults in 1990)



6. DISCUSSION

The series of observational surveys of bicycle usage and helmet wearing habits conducted by MUARC has provided the basis for an evaluation of the effectiveness of the bicycle helmet wearing law introduced in Victoria in 1990. Three of these surveys were conducted during the same time of the year (May) and have therefore adjusted for seasonal variations in bicycling habits. On the other hand, the first survey was carried out in November-January and, although some of the results from the 1987/88 survey have been included in this evaluation, it must be remembered that they represent a different time of the year, some 2.5 years before the implementation of the compulsory helmet wearing law.

In terms of the profile of bicyclists observed, the post-law sex distribution of observed bicyclists was identical to that prior to the law. However, for bicyclists of both sexes, there were fewer teenagers in 1991 and 1992 compared to pre-law levels. By 1992, there had been a 29% reduction in the proportion of teenage females and a 35% drop in the proportion of males of the same age. In all surveys, adults were the major users of arterial roads, and teenagers the major users of non-arterial roads.

6.1 HELMET WEARING RATES

This evaluation of helmet wearing rates, based on a series of observations on 64 sites in metropolitan Melbourne, has confirmed Cameron et al's (1992) preliminary findings of a post-law increase in helmet wearing rates in all age-groups. In children, wearing rates rose from 65% pre-law to a post-law level of 78% in 1991. Adult rates rose from 36% in 1990 to 74% in 1991. Teenage helmet wearing rates remain the lowest of all three age groups but had risen significantly from a pre-law level of 21% to 45% in 1991.

Two years after the introduction of the law, helmet wearing rates have remained at high levels. By 1992, the rate has remained constant in children but increased to 59% in teenagers and 84% in adults. These rates are greater than the corresponding pre-law levels in all age-groups. Amongst children, post-law rates were 1.2 times the pre-law level; in teenagers this ratio was 2.9 times and in adults it was 2.0 times.

These results suggest that the mandatory law is continuing to have a major positive influence on helmet wearing rates in all age-groups, but particularly the teenagers. The magnitude of the increase in wearing rates in teenagers is also a reflection of the low level of helmet wearing to begin with in this group. In fact, in 1992, teenage helmet wearing rates were still well below those in other age-groups, suggesting that continued interventions need to be targeted specifically towards this group. In addition, it remains to be established whether helmet wearing rates in this group will approach the level in adults and younger children with continuing enforcement. One might anticipate a cohort effect to operate whereby younger children already wearing helmets continue to do so once they enter the teenage age-group. Further examination of this issue needs to be conducted.

In all age groups, helmet wearing rates were higher in teenage and adult bicyclists observed in arterial zones than non-arterial zones. This probably reflects their perceived increased risk of accident involvement in arterial zones. On the other hand, in 1992, only 69% of child bicyclists in arterial zones wore helmets as opposed to 81% in local zones. This is of some concern because the arterial road presents higher risks of accident involvement and head protection is essential to reduce the severity of head injury in the case of an accident. However, it should be noted that children account for less than 7% of all arterial road users and this is not likely to be a major concern in the overall population of bicyclists.

Bicyclists' perceived risk of involvement is also reflected in their helmet wearing habits when riding on the footpath rather than on the road. Although footpath bicycling is illegal, it may be perceived to be a safer environment for bicycling, particularly for children. Helmet wearing rates are lower in footpath bicyclists rather than in those who ride on the road itself. Alternatively, this may be due to bicyclists who disregard the footpath riding law also being more likely to disregard the helmet wearing law.

6.2 HELMET WEARING BEHAVIOURS

During the 1991 and 1992 MUARC surveys, information was collected on various helmet wearing behaviours. These included whether the bicyclist was carrying a helmet rather than wearing one, whether the helmet's chin strap was securely fastened and the type of helmet being worn. These factors all influence the relative protection afforded by the helmet and the protection afforded by such devices should be examined in terms of these factors. This information was not available prior to the introduction of the law and so is only a measure of the continuing influence of the helmet wearing law.

By combining the numbers of bicyclists carrying helmets, but not wearing them with the number of helmet wearers, an estimate of helmet ownership has been obtained. Helmet ownership rates decreased from 82% in 1991 to 78% in 1992 amongst children but increased in the other age groups (teenagers from 57% to 65%; adults from 76% to 86%). Amongst helmet owners, there was a slight increase in the proportion of bicyclists wearing helmets in 1992 compared to 1991 for children and adults, and a much larger increase for teenage helmet owners (from 80% in 1991 to 94% in 1992).

These findings provide a partial explanation for the changes in helmet wearing rates observed between 1991 and 1992 (Section 5.2.2). Whilst the proportion of child helmet owners wearing their helmets has increased, there were fewer owners in 1992. This could explain the (non-significant) decrease in overall helmet wearing rates in this age group. On the other hand, helmet ownership has increased in adults and teenagers and this could account for some of the increase in overall helmet wearing rates in this group. In teenagers, in particular, the increase in the proportion of helmet owners wearing their helmets has been quite large (80% in 1991 versus 94% in 1992). It is obvious that this change must explain part of the increase in helmet wearing rates in teenagers.

Cameron et al found an indication that increased helmet wearing in the first 12 months following the introduction of the law had not been as effective in reducing the risk of head injury to crash-involved bicyclists as would have been predicted by extrapolation of the pre-law trends (Cameron et al, 1992). Furthermore, this apparent reduced effectiveness seemed to apply predominantly to adult bicyclists and, to a lesser extent, teenagers. The report further suggested that if this was a true effect then it could be due to helmets being less securely adjusted or fastened by those bicyclists who did not previously wear them (perhaps mainly the teenage group), or possibly to the greater proportion of lighter, soft-shell helmets being worn as a result of the amendment to the Australian Standard for bicycle helmets in 1990 (perhaps mainly affecting the adult group). Alternatively, this apparent result could be due to the assumptions which had been made in combining a range of helmet wearing data and extrapolating relationships with head injuries to make the predictions.

Although no data prior to June 1990 is available to assess the validity of these suggestions, the 1991 and 1992 MUARC surveys can be used to assess trends in helmet wearing associated behaviours after the law. In 1991, one year after the law was introduced, the proportion of bicyclists (of each age and sex) with their chin straps done up exceeded 99% in all but male teenagers for whom the rate was 94%; by 1992, the male teenage rate had increased to 97%. It is unlikely therefore, given the large proportion of bicyclists correctly wearing their helmets, that this factor could explain the Cameron et al finding.

The 1991 and 1992 surveys indicated a decreasing preference for hard-shell helmets with increasing age. In 1991, 12% of children, 30% of teenagers and 53% of adults wore soft-shell helmets. By 1992, the proportions of soft-shell helmets had fallen in each age-group (11% in children, 27% in teenagers and 42% in adults). These figures might explain at least part of the apparent reduced effectiveness of helmets indicated by Cameron et al but this would warrant further detailed investigation to reach a cause-and-effect conclusion. A study currently being undertaken by MUARC in conjunction with Technisearch is addressing this issue further by directly testing the protective ability of different types of helmets which have sustained an impact in a real crash.

6.3 BICYCLE EXPOSURE

Experience in the public health arena has shown that any intervention, such as the introduction of a mandatory law like the helmet-wearing one, could have unintentional effects on the behaviour of a community in addition to the anticipated positive ones. In the case of the intervention being considered here, an unintentional outcome might result in a reduction in the number of people riding their bicycles. Some people without helmets may no longer ride their bicycles because they know that they are breaking the law if they do so. Others may refuse to purchase a helmet altogether because they do not see the benefits of wearing one and consequently give up bicycling as an activity. There may also be a group of bicyclists who, in the recent tough economic times, cannot afford to buy one.

The incidence of both intended and unintended effects of the bicycle helmet wearing law can be assessed by exposure studies. In this context, exposure is defined to be the amount of bicycling undertaken by a group or individual and, for the purposes of this study, has been calculated in two ways. The first of these was by a computed estimate of bicycle exposure (in seconds of bicycling per week in metropolitan Melbourne). This type of exposure measure is a time based one and can be used to measure the likely risk of involvement over a given period. In terms of the unintentional effects described above, this measure would reflect such outcomes by a reduction in the amount of time spent in bicycling activity. The number of bicyclists observed, during a given time period, is the second measure of exposure. Being a count in a specified unit of time, it provides a measure of the per-person exposure. Anecdotal reports have claimed that the introduction of the bicycle helmet wearing law has been accompanied by "a reduction in the number of people riding their bicycles". Assessment of the observed counts of bicyclists would provide data to support or dispute this claim.

When assessing whether the introduction of the law has had an unintentional effect on bicyclists as a group, two approaches were used to assess changes in bicycle use over the period of time covered by the MUARC surveys. The first of these was based on a comparison of the computed time-based exposure estimates across the 64 sites consistently observed across the survey series. A major disadvantage of this approach, however, is the lack of available data for adults in 1990. This means that the pre- and post-intervention comparisons of exposure in adults had to be made on the basis of the 1987/88 survey instead. Further complicating this comparison is the fact that the data was collected at different times of the year and that there was nearly 3.5 years between the earlier survey and the one in 1991. Conclusions drawn from an evaluation of trends in adult exposure on this basis must therefore be interpreted with caution.

Evaluation of the estimated bicycle use in Melbourne (billions of seconds per week) indicated that overall total bicycle exposure had decreased during the survey periods but that adults had increased their exposure. Based on the comparison with the first survey in the series, bicycle usage in adults had doubled over the period Dec 1987-May 1992. However, exposure in children in 1992 was 10% less than the pre-law levels assessed in 1990 and teenage exposure had decreased by 46%. The majority of this decrease in teenagers (44%) occurred in the first year after the law was introduced. On the basis of these results, it appears that the compulsory helmet wearing law had no deleterious effect on adult

bicyclists but that it has had a moderate effect on children and a major effect in teenagers immediately after its implementation.

Examination of the counts of bicyclists observed during each of the MUARC surveys indicated that there had been a drop in the number of bicyclists during the first year after the law was introduced. This drop was greatest in teenagers who might well have been the group most influenced by the helmet wearing law (as evidenced by the fall in timed exposure). The decrease in children was a continuation of a decline in child numbers that was already apparent before the law. Based on these figures, it would seem that the introduction of the law probably had an immediate effect on the number of teenage bicyclists. However, during the period 1991-1992, there was an increase in the number of bicyclists of all ages. As a result of these increases, the number of adult and child bicyclists in 1992 was not much smaller than the observed numbers in 1990. However the number of teenage bicyclists was still considerably less than the pre-law levels.

A partial explanation for these results relates to trends in the time block, or time of the week, during which bicyclists were observed during each of the surveys. In terms of time block distribution, the 1990 and 1992 surveys were very similar. In 1991, however, there were fewer bicyclists on the weekend compared to these two other surveys. This may also be related to the weather patterns occurring during the survey. In 1991, half of all weekend observation sessions coincided with rain as opposed to an average of 32% of sessions in 1990 and 14% in 1992.

This observation raises the question as to the possible influence of weather patterns on the observed differences in pre- and post-law numbers of bicyclists. One of the problems with conducting a series of observational surveys of this nature is that, even though the surveys can be constrained to occur during the same time of the year, extrinsic factors such as weather cannot be accounted for in their design. There is always the possibility that such factors could have a bearing on the results obtained , thereby making it necessary to place certain caveats on any conclusions. In order to explore this issue further for the 1990 and 1991 surveys, a site was classified as "fine" if there was no rain during any of the observation sessions conducted there. A "rainy" site was therefore defined to be one where rain fell during at least one of the observation periods. Eighty-two percent of all sites had the same weather classification during both the 1990 and 1991 surveys. The table below examines the reduction in the number of bicyclists observed in the sites that were consistently fine during the 1990 and 1991 surveys and compares this to the corresponding reduction in all sites combined.

	Percent reduction in the numbers of bicyclists observed in 1991 compared to 1990	
Age-group (years)	**Sites that were fine in both 1990 and 1991**	**All sites observed in 1990 and 1991**
5-11	2%	24%
12-17	41%	46%
18+	13%	29%
All ages	24%	36%

If weather was not a factor in the decreasing numbers of bicyclists between 1990 and 1991, then the percent reduction in the sites that were consistently fine might be expected to be the same as that for all sites. The table above, however, shows that weather may have had an influence since the percent reduction in the overall numbers of bicyclists was 24% in fine sites and 36% in all sites. Amongst children and adults, the reduction in the numbers of bicyclists was considerably less in fine sites than in

all sites. This suggests that the weather may have had an influence on bicycling in these two groups. On the other hand, the data indicate that weather patterns may have had little influence on the numbers of teenage bicyclists suggesting that the introduction of the law was a more important factor affecting exposure for this age group. This supports the other findings suggesting that the law had its greatest influence on teenagers.

Another explanation for some of the increase in bicyclist numbers in 1992 is related to the fact that there appears to have been a bicycle rally passing through one of the sites (site 80, in 1991/2, Appendix 2) on a Sunday morning. This particular site is a popular recreational area and is part of a defined bicycle track. In 1991, it was rainy during all observations of this site and very few bicyclists were observed. Although the weather was generally fine in 1990, the number of bicyclists in 1992 in this area was still more than would have been expected on the basis of pre-law levels. The chance occurrence of a large group of bicyclists passing through a particular area is one of the hazards of observational surveys such as these. From a statistical point of view, however, an occurrence such as this is a true observation, well within the bounds of "normal" behaviour for that time period, and cannot be excluded from the analysis.

The chance occurrence of events such as different weather conditions or large groups of bicyclists, as described above, can be a problem associated with observational surveys even though observation sessions are randomly allocated within time and space strata. Such problems can be overcome, or minimised, by conducting larger surveys. Analysis methods, however, cannot overcome such problems (eg. by focussing on "fine" sites only) because it upsets the matched 64 site comparison of 1990 versus 1991.

The importance of the analysis of the total numbers of bicyclists as a measure of exposure trends is that it enables an assessment of trends in adults because, unlike timed-exposure, this information was available in 1990, prior to the law. This means that to have a valid comparison of pre- and post- law levels in adults, we have no choice but to look at the number of bicyclists over time. On the other hand, comparisons of the numbers of bicyclists leads only to valid conclusions about the 64 observation sites in common to each of the MUARC surveys. Unlike the timed exposure data, these results cannot, and should not, be extrapolated to the whole of metropolitan Melbourne; they only describe the 64 sampled sites.

There is an apparent contradiction in the conclusions that would be drawn from the two separate exposure analyses. This can be explained by the average exposure (time spent bicycling) per bicyclist. Although the number of children observed was less than in any other age group, the average amount of time spent on the road was highest for this group during each survey. Adults, the most numerous group, spent the least amount of time bicycling, on average. This may just reflect the fact that, per unit distance, adults can travel at a greater speed. By definition, the speed at which bicyclists travel is an important factor in determining timed-exposure in these studies. Since the definition of timed-exposure in this study was based on a weighting of recorded bicycling times in a specified observation site of fixed length, it is feasible that if bicyclists are riding faster than they used to (ie travelling further distances per unit time), then for a given observation period and site, the exposure would be expected to decrease, even if there were more bicyclists on the road.

Examination of average bicycle exposure (per bicyclist) figures suggests therefore that the decline in bicycle use from 1990 to 1991 for each age group was due to decreases in both the average bicycling time and fewer bicyclists. On the other hand, the decline in total bicycle exposure between 1991 and 1992 in children and teenagers may be due to a decline in the average time spent bicycling rather than due to fewer bicyclists of this age riding their bikes. Although average exposure per bicyclist also

decreased in adults, the increase in the number observed in 1992 over 1991 accounts for the increase in total bicycle exposure in this group.

7. CONCLUSION

The mandatory helmet wearing law has achieved its goal of increasing bicycle helmet wearing rates for all groups of bicyclists throughout metropolitan Melbourne. Two years after its introduction, high levels of helmet wearing have been maintained in adults and children. Both adult and teenage rates, in particular, are continuing to increase.

The first year following the introduction of the helmet wearing law coincided with a reduction in the number of people riding their bicycles, particularly amongst 12-17 year olds. By 1992, two years after the law, the number of bicyclists was approaching pre-law levels in adults and children but were still greatly reduced in teenagers.

ACKNOWLEDGMENTS

VICROADS sponsored these observational surveys and MUARC would like to thank Fairlie Nassau, in particular, for her support.

The studies would not have been possible without the dedication of the study supervisors Wendy Watson and David Kenny. The assistance of the observers and other study participants is gratefully acknowledged.

The authors of this report thank Dr Peter Vulcan and Max Cameron for their support and advice. In addition, Tri Le is thanked for his assistance with preparing the figures and Glenda Cairns for preparing the final manuscript.

REFERENCES

Cameron, M., Heiman, L. & Neiger, D. *Evaluation of the bicycle helmet wearing law in Victoria during its first 12 months,* Report No. 32, Monash University Accident Research Centre, 1992.

Drummond, A.E. & Jee, F.M. *The risks of bicyclist accident involvement,* Report No. 2, Monash University Accident Research Centre, October, 1988.

Drummond, A.E. & Ozanne-Smith, E.J. *The behaviour and crash involvement risk of child pedestrians and bicyclists: a traffic exposure study,* Report No. 17, Monash University Accident Research Centre, July, 1991.

Leicester, P., Nassau, F. & Wise, A. *The introduction of compulsory helmet wearing in Victoria,* VIC ROADS, Report No. GR/91-4, 1991.

Roads and Traffic Authority, *Road traffic accidents in New South Wales. Statistical statement: Year ended 31st December 1991,* Rosebery, New South Wales: Roads and Traffic Authority, 1991.

Vulcan, P., Cameron, M.H. & Watson, W.L. 'Mandatory bicycle helmet use: experience in Victoria, Australia', *World Journal of Surgery*, Vol 16, May, 1992.

Walker, M.B. *Law compliance and helmet wearing among cyclists in New South Wales, April 1991,* Sydney: Roads and Traffic Authority, Consultant Report CR 1/91, 1991.

Walker, M.B. *Law compliance among cyclists in New South Wales, April 1992,* New South Wales Roads and Traffic Authority, Network Efficiency Branch, 1992.

APPENDIX 1

TIMETABLE OF EVENTS RELATING TO THE USE OF BICYCLE HELMETS IN VICTORIA

1961	Motorcyclists required to wear approved helmets.
1970	Compulsory seat belt legislation introduced; supported by publicity and enforcement.
1975	Child restraint laws introduced; supported by publicity and enforcement.
Mid 1970's	Some bicyclists were wearing helmets. A new generation of bicycle helmets became available, some of which met the basic design criteria.
1976	Random breath testing introduced; supported by publicity and enforcement.
1977	Australian Standard for "General Purpose Protective Helmets (for use in pedal bicycling, horse riding and other activities requiring similar protection)" developed.
1978	Higher penalties and licence cancellation directed against drink driving introduced.
1979	Introduction of legislation governing engine capacity limits for novice motorcyclists.
1980	"Bike-Ed", education program about bicycle safety targeted at students aged 9-13 years began. Bicycle helmet use promoted.
1981	**(Oct)** First helmet certified as meeting the Australian Standard. **(Dec)** Royal Australian College of Surgeons meeting of interested organisations to discuss different approaches to helmet promotion.
1982	Bulk helmet purchase scheme established by the Road Safety and Traffic Authority in co-operation with one Education Department region. Helmets available through schools at approx $30 (33% discount). 1000 helmets available in total. McDermott and King paper in the Medical Journal of Australia - *Differences in head injuries of pedal cyclist and motorcyclist casualties in Victoria.* A second helmet manufacturer received Australian Standards approval and the Road Traffic Authority commenced advertising aimed at mothers, urging that they purchase helmets for their children.
1983	**(Jan)** Education Department regulation for helmets to be worn in all state school bicycling activities, including "Bike-Ed".

(March) VIC ROADS survey on helmet wearing in commuter and school children bicyclists in Melbourne.

(Sept) Publication of a report to the Road Traffic Authority by Elliott and Associates: *Bicycle helmet research* describing the attitudes of bicyclists to wearing helmets. Study carried out in preparation for a major publicity campaign.

Also:

Further bulk helmet purchase schemes organised through Education Department Regions and individual schools. Guidelines for a modified bulk purchase scheme involving discount through arrangements with retailers were developed.

1984

(March) VIC ROADS survey on helmet wearing in commuter and school children bicyclists in Melbourne.

(March) Public education via two television commercials, radio and a pamphlet launched. (Publicity campaign lasted for 2 months, but the commercials continued to appear for many more months.)

(Sept) Road Traffic Authority display at the Royal Melbourne Show featured bicycle helmet safety.

(Oct) Statement in Parliament by the Minister for Transport stating that the government would move towards compulsory helmet wearing legislation.

(Nov) Posters distributed to all 7,000 doctors in Victoria.

(**Dec)** Government rebate offered on helmet purchases - $10 over the Christmas period; Australian made helmets only.

Also:

Further bulk helmet purchase schemes.

The Road Traffic Authority of Victoria established a Bicycle Helmet Promotion Task Force to assist in popularising helmet-wearing. Membership included the Bicycle Institute of Victoria, Brain Foundation, Child Accident Prevention Foundation of Australia, Education Department, Police Department, Royal Australasian College of Surgeons, Royal Automobile Club of Victoria, State Bicycle Committee, bicycle retailers, helmet importers and helmet manufacturers.

Further provision of assistance to organisers of bulk helmet purchasing schemes, mainly in Education Department Regions, but generally using designated retailers. Guidelines for bulk purchase schemes disseminated.

Dorsch, Woodward and Somers study from the Road Research Unit, University of Adelaide - *Do bicycle safety helmets reduce severity of head injury in real crashes?*

Petition signed by 5000 citizens given to the Victorian government requesting it assist in reducing helmet purchase costs.

Four imported helmets received Australian Standards Association approval.

1985 **(Feb)** A $5 rebate scheme began covering all approved helmets purchased during 29/12/84-9/3/85. The Minister for Transport stated publicly that the government intends to make the use of bicycle helmets compulsory by July 1, 1985; this was not actually achieved until 5 years later.

(Feb) A new television commercial featuring Australian Olympic Games bicycling Gold Medallist Dean Woods was launched to coincide with the rebate scheme.

(March) VIC ROADS survey on helmet wearing in commuter and school children bicyclists in Melbourne and country Victoria.

(**Dec)** Government rebate of $10 offered on helmet purchases.

Also:

Country surveys of bicycle use began.

McDermott and Klug paper in the Medical Journal of Australia - *Head injury predominance: pedal cyclists vs motor-cyclists.*

1986 **(March)** VIC ROADS survey on helmet wearing in commuter and school children bicyclists in Melbourne and country Victoria.

(May) Letter from McDermott, on behalf of the Road Trauma Committee, to the Editor of the Medical Journal of Australia - *Safety helmets for pedal cyclists.* "Helmet usage has now achieved sufficient community acceptance to make legislation for compulsory wearing practical."

(Dec) Government rebate of $10 offered on helmet purchases.

(Dec) Report on an Inquiry into Child Pedestrian and Bicycle Safety by the Social Development Committee of the Victorian Parliament.

Also:

Report by Healy, Road Traffic Authority released - *Trends in helmet usage rates and bicyclist numbers sustaining head injury-July 1981 to December 1985 - Victoria.*

1987 **(March)** VIC ROADS survey on helmet wearing in commuter and school children bicyclists in Melbourne and country Victoria.

(March) VIC ROADS survey on recreational bicycling rates in metropolitan Melbourne and country Victoria.

(Nov-Dec) MUARC observational survey of bicycle exposure and bicyclist behaviour.

(Dec) Road Traffic Authority strategy for introducing helmet legislation developed.

(Dec) Government rebate of $10 offered on helmet purchases.

1988 **(Jan)** MUARC observational survey of bicycle exposure and bicycle behaviour.

(March) VIC ROADS survey on helmet wearing in commuter and school children bicyclists in Melbourne and country Victoria.

(March) VIC ROADS survey of recreational bicycling rates in metropolitan Melbourne and country Victoria.

(Oct) Release of report by Drummond and Jee - *The risks of bicyclist accident involvement.* Study was commissioned by the Road Traffic Authority and the State Bicycle Committee.

(Dec) Government rebate of $10 offered on helmet purchases.

Also:

Wood and Milne paper in Accident Analysis and Prevention - *Head injuries to pedal cyclists and the promotion of helmet use in Victoria, Australia.*

1989

(Jan-Feb) Government rebate of $10 offered on helmet purchases.

(March) VIC ROADS survey on helmet wearing in commuter and school children bicyclists in Melbourne and country Victoria.

(March) VIC ROADS survey of recreational bicycling rates in metropolitan Melbourne and country Victoria.

(From July - June '90) 2836 Bicycle Offence Penalty Notices given.

(From July - June '90) 1743 Bicycle Offence Reports.

(Sept) The Minister for Transport and the Minister for Police and Emergency Services announce new regulation requiring bicyclists to wear an approved helmet whilst bicycling in Victoria to take effect from July 1990.

(Dec) Major initiative aimed at drink driving.

(Dec) Government rebate of $10 offered on helmet purchases to dependents 16 years and under of low income families.

Also:

Thompson, Rivara and Thompson paper in the New England Journal of Medicine - *A case-control study of the effectiveness of bicycle safety helmets.*

Report by Williams, Technisearch Ltd, RMIT - *The protective performance of bicyclists' helmets in accidents.*

Australian Standard for bicycle helmets under review.

1990

(March) VIC ROADS survey on helmet wearing in commuter and school children bicyclists in Melbourne and country Victoria.

(March) VIC ROADS survey of recreational bicycling rates in metropolitan Melbourne and country Victoria.

(March) Major initiative aimed at speeding.

(April) VIC ROADS approval was introduced as an interim measure pending amendment of the Australian Standard AS 2063.2. This allowed the newer, lighter-weight style helmets to be approved.

(May-June) MUARC observational survey of child traffic behaviour (both as pedestrians and bicyclists). Helmet wearing rates observed in children and adults.

(July) VIC ROADS survey on helmet wearing in commuter and school children bicyclists in Melbourne and country Victoria.

(July - June '91) 19,229 Bicycle Offence Penalty notices given.

(July - June '91) 5028 Bicycle Offence reports.

(JULY) INTRODUCTION OF THE MANDATORY BICYCLE HELMET USE LAW IN VICTORIA.

(Oct) VIC ROADS survey on helmet wearing in commuter and school children bicyclists in Melbourne and country Victoria.

1991

(Jan) Compulsory helmet wearing law introduced in New South Wales for those aged 16+ years.

(March) VIC ROADS survey on helmet wearing in commuter and school children bicyclists in Melbourne and country Victoria.

(March) VIC ROADS survey of recreational bicycling rates in metropolitan Melbourne and country Victoria.

(May) MUARC observational survey of bicycle exposure and helmet waering behaviours.

(May/June) Recreational and commuter bicycle use assessed by MUARC in an observational survey in Melbourne.

(July) Compulsory helmet wearing law introduced in New South Wales for children.

Also:

Williams paper published in Accident Research and Prevention - *The protective performance of bicyclists' helmets in accidents.*

1992

(April) Lightweight helmets receiving certification to the Australian Standard no longer needed VIC ROADS approval.

(May) MUARC observational survey of bicycle exposure and helmet wearing behaviours.

(May/June) Recreational and commuter bicycle use assessed by MUARC in an observational survey in Melbourne.

(July) Report by MUARC - *Evaluation of the bicycle helmet wearing law in Victoria during its first 12 months*.

(July) Report by NSW RTA - *Law compliance among cyclists in New South Wales, April 1992.*

APPENDIX 2
LISTING OF SITES OBSERVED DURING THE MUARC SERIES OF OBSERVATIONAL SURVEYS

North West Region

Arterial Sites [8]

Site No.	Melway Ref.	Sampled Street	Intersecting Street	Direction from I/Section
1	40 G3	Graham St	Wright St	North
2	13 G8	Taylors Rd	Kings Rd	East
3	56 G2	Todd Rd	Williamstown Rd	North
4*	17 G12	Sydney Rd	Bell St	North
5*	14 A1	Keilor-Menton Rd	Sunshine Ave	West
6	16 G3	Pascoe Vale Rd	Glenroy Rd	North
7	26 A1	St. Albans Rd	Main Rd	N/West
8†	53 B11	Aviation Rd	Central Ave	South

Non-Arterial Sites [15]

9	54 B9	Chester Rd	Aberdeen Rd	West
10	27 C6	Monmouth St	Thompson St	North
11	29 D2	Aberdeen St	Melville St	N/East
12	04 G10	Arundle Rd	McNab Rd	S/East
13†	28 J7	Alexander Ave	Pascoe Vale Rd	East
14	54 J10	Bayview St	Civic Pde	South
15†	17 B3	Stella St	West St	West
16	27 D5	Davis Ave	Doyle St	West
17	13 D10	Cheleon Way	Tollhouse Rd	South
18*	25 K2	Andrea St	Glendinning St	West
19*	209 E9	Cuttris Rd	Diggers Rd	West
20†	41 F4	Cala St	Sunshine Rd	South
21	13 E8	Braeswood Rd	Taylors Rd	South
22*	25 E10	Railway Pde	Station Rd	West
23	26 C6	Glenmaggie Dr	Merrimu Gve	South

North East Region

Arterial Sites [6]

24†	12 G2	Wilson Rd	Hurstbridge Rd	West
25	45 K2	Kilby Rd	Burke Rd	West
26	20 G2	Grimshaw St	Greensborough Rd	East
27*	19 J1	Grimshaw St	Plenty Rd	East
28*	45 A8	High St	Barkers Rd	North
29	30 H11	Victoria Rd	Westgarth St	North

*observed in 1987/88 survey only

† observed during 1987/88 and 1990 surveys only

Non-Arterial Sites [10]

Site No.	Melway Ref.	Sampled Street	Intersecting Street	Direction from I/Section
30	46 K9	Hight St	Beatty St	N/East
31	12 A6	Fyffe St	Norma St	North
32†	20 H6	Warralong Ave	Kanowindra Cr	East
33	31 G1	Law St	Bonar St	South
34†	30 J10	Russel St	Bank St	South
35	12 D2	Collard Dr	Bellbird Rd	S/East
36	12 D5	Perversi Ave	Hurstbridge Rd	East
37	18 J9	Tylers St	Joffre St	West
38	31 J5	Odenwald Rd	Alandale Rd	East
39	10 B11	David Cr	Trafalgar Cr	East

Outer Eastern Region

Arterial Sites [10]

40	82 K12	Hallam North Rd	Churchill Park Dr	South
41*	49 D9	Heatherdale Rd	Maroodah Hwy	South
42	73 B11	Kellets Rd	Taylors La	West
43*	33 B4	Templestowe Rd	Thomspons Rd	West
44	62 D7	Burwood Hwy	Springvale Rd	East
45	73 K4	Burwood Hwy	Dorset Rd	S/EAst
46†	36 H12	Yarra Rd	Plymouth Rd	East
47	36 H12	Plymouth Rd	Yarra Rd	East
48	51 E10	Canterbury Rd	Colchester Rd	East
49*	32 E5	Templestowe Rd	Bridge St	North

Non-Arterial Sites [16]

50	70 C7	Viewbank Rd	Ferntree Gully Rd	North
51	32 E9	Stanley St	Barak St	West
52†	64 F2	Bungalook Rd	Elmhurst Rd	South
53	34 E5	Larnoo Dr	Creek Rd	East
54	63 F8	Quixley Gv	Abbey Cr	S/East
55	90 K10	Tristania St	Paperbark St	South
56	70 E2	William St	Stephensons Rd	West
57	80 J1	Wahlley Dr	Bracken Cr	East
58	65 C1	Kreswick Cr	Parkstone Dr	South
59†	34 A11	Saxonwood Rd	Regency Pl	West
60	74 E4	Ladys Wlk	Walbury Ave	S/West
61*	90 K8	Ash St	Pittosporum Gv	South
62	34 A8	Tuckers Rd	Burleigh Dr	North
63†	61 J7	Highview Gv	Dorothy St	South
64	33 B7	MacEadon Rd	Mayfair Ave	South
65*	91 E12	Alexander St	Albert Rd	West

Inner South Eastern Region

Arterial Sites [6]

Site No.	Melway Ref.	Sampled Street	Intersecting Street	Direction from I/Section
66	44 D4	Johnston St	Hoddle St	East
67*	58 B9	Alma Rd	Barkly St	East
68	67 A3	Ormond Espl	Barkly St	S/East
69*	58 K9	Dandenong Rd	Kooyong Rd	West
70*	44 K12	Swan St	Maddey St	West
71*	56 G2	Williamstown Rd	The Boulevard	West

Non-Arterial Sites [8]

72*	56 F3	Mayne Rd	Williamstown Rd	S/West
73	58 K9	Armadale St	Wattletree Rd	North
74	58 A5	Queens La	Roy St	S/East
75	58 H10	Montague Ave	Holroyd Ave	South
76	43 G10	Whiteman St	Queensbridge St	S/West
77	57 H5	Nimmo St	Canterbury Rd	S/West
78*	30 C11	Railway St	Apperley St	East
79*	58 H4	Brookville Rd	Mathoura Rd	East

Southern Region

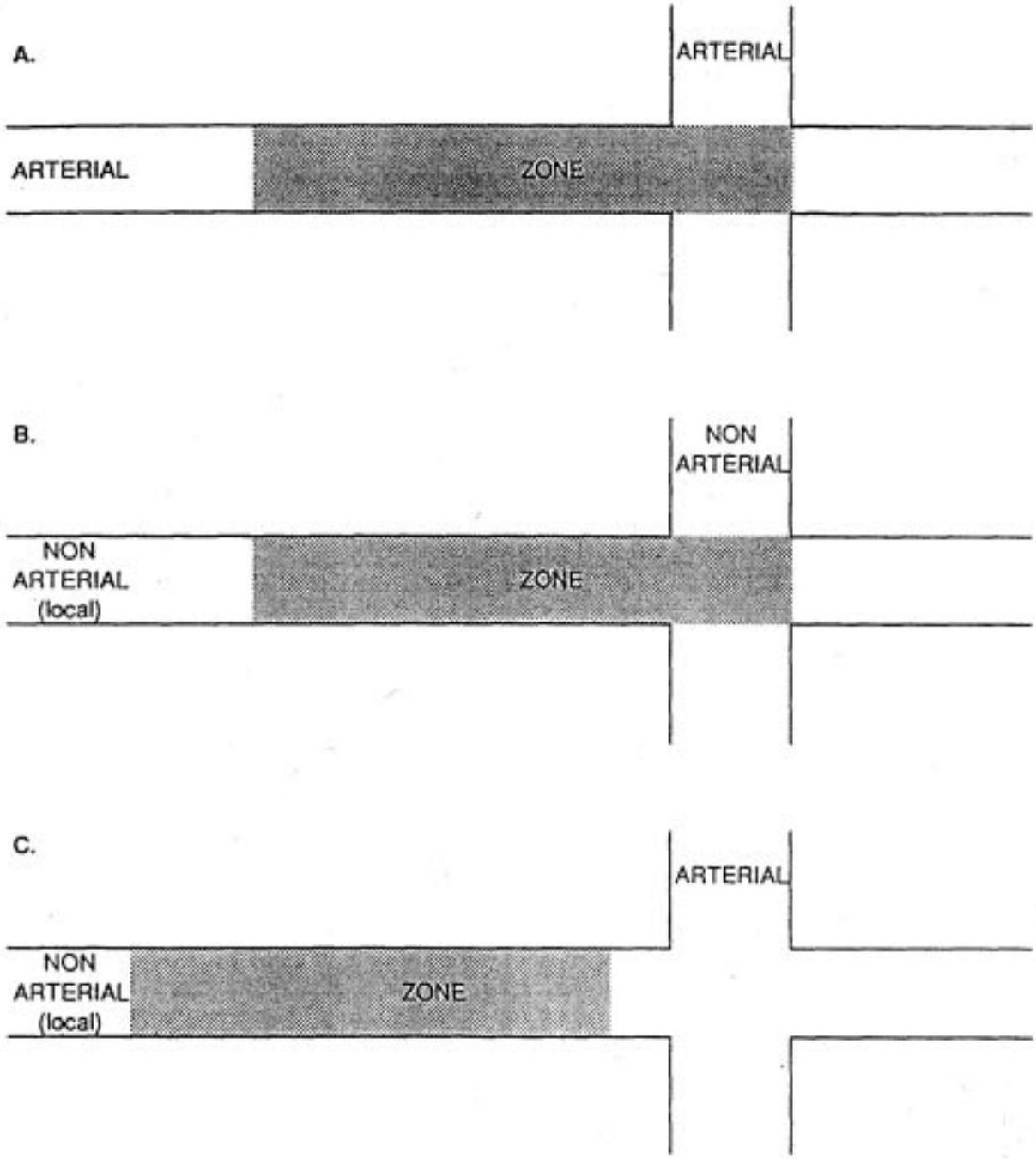
Arterial Sites [10]

80	86 H7	Beach Rd	Charman Rd	East
81	78 E2	Warrigal Rd	Centre Rd	South
82*	79 H6	Westall Rd	Rayhur St	South
83	90 F7	Stud Rd	Clow St	N/East
84	106 A8	Moorooduc Rd	Two Bays Rd	N/East
85	85 K4	Bluff Rd	Beach Rd	North
86†	67 K12	Centre Rd	Nepean Hwy	West
87	68 B8	North Rd	Bambra Rd	East
88*	93 F6	Edithvale Rd	Wells Rd	S/East
89*	102 C3	Davey St	Nepean Hwy	East

Non-arterial sites [16]

90†	77 B5	Roydon St	Wishart St	East
91	97 F7	Dahmen St	McLeod Rd	North
92	95 C1	Hammond Rd	Rhur Ct	South
93	92 F1	Albert St	Park St	S/East
94†	77 H7	Genoa St	Bulli St	East
95	86 D7	John St	Edith St	East
96	81 B6	Blaxland Dve	Police Rd	South
97	103 D3	Lucerne Cr	Sassafras Dve	South
98	105 J7	Lower Cr	Batman Ave	West
99	80 C8	Birmingham St	Audrey St	West
100*	69 H10	Gadd St	Brighton St	North
101†	78 J7	Carbine Ave	Elder St	East
102	67 H5	Gladstone Pde	Harrington St	South
103	92 F2	Alfred St	Bowman St	N/East
104	78 G9	Henry St	Willis St	West
105*	90 G6	Ross St	Herbert St	South

APPENDIX 3
OBSERVATION ZONE DEFINITIONS



Note that non-arterial (local) street zones exclude the intersection with an arterial (major) road, thus commencing 2-3 metres down the arterial street (see Figure C). When both streets are non-arterial the intersection is included (see Figure B).

An arterial road is shown in Melways as a black or red line.

1992 CYCLIST SURVEY

Site Summary Form

Observer's Name

SITE DETAILS

Site No. .....

Street Name .....
Site Boundary .....
Site Length ..... (metres)

Road Class:

Arterial	**1**
Local	**2**

Land Use:

Residential	**1**
Shops	**2**
Inudstrial	**3**
Parks/school/pre-school	**4**
Other	**5**

Specify.....

TIME

Date: .....

Day:

Sunday
Monday
Tuesday
Wednesday
Thursday
Friday
Saturday

Time Block:

Weekday AM
Weekday PM
Weekend AM
Weekend PM

Weather:

Hour	fine = 1, rain = 2
1	
2	
3	
4	
5	

1992 CYCLIST SURVEY

Data Collection Form

Site No. …… Date ……

Hour 1 2 3 4 5

Cyclist	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Road time (secs)																				
Footpath time (secs)																				
Road Entry mid-block = 1 intersection = 2																				
Age (estimated)																				
Sex M/F																				
Helmet worn yes = 1 no = 2																				
Helmet done up yes = 1 no = 2																				
Helmet carried yes = 1 no = 2																				
Helmet type hard-shell = 1 foam only = 2 other = 3																				

APPENDIX 5
OPERATIONAL DEFINITIONS

SITE SUMMARY FORM

Site No.; Road Class: Predetermined (see list of sites)

Observation zone: See attached diagrams for definitions of arterial and non-arterial (local street) zones.

Note: local street zones exclude the intersection with a major road, thus commencing 2-3 metres down the local street. Local street intersections are included.

Site Boundary: Where the zone of approximately 150 metres is between two identifiable points (e.g. streets) in Melways, the site length can be calculated by MUARC. In this case record the street name (or landmark shown in the Melways) at the site boundary.

Site Length: If there is no street or landmark recorded in the Melways bounding the site, choose a point which you can identify (e.g. letter-box, brick fence, etc.) and pace out the site length (1 pace = approx. 1 metre). Record the site length in metres on the Site Summary Form. If it is not practical to pace out the full 150 metres because the boundary would be out of view from your observation point (e.g. because the road bends out of view), pace out the distance that is within view and record this on the Site Summary Form. **In all cases make a note describing the point you used to define the boundary in such a way that it can be identified by others.**

Land Use: Classify as 1, 2, 3 or 4 according to principal land use. Under **Other** (5), specify other pedestrian or cyclist generators such as public transport stop, a shop in a residential area, etc.

Weather: Code as raining if it rains heavily for 10-15 minutes or more in the hour, or lightly (drizzle) for 20-30 minutes or more in the hour.

DATA COLLECTION FORM

Hour: Record the hour of the observation session at the top of the worksheet for each hour of the session. Start a new data collection form for each hour of observation. Therefore, for each observation session you should use five data collection forms.

Note: only 50 minutes of data collection is required for each hour of observation. However, 50 minutes of observation must occur in each separate hour and the ten minute breaks cannot be skipped so that the session finishes early but it is possible to join the ten minute breaks between two sessions (at the end of one and the start of the other) to give a 20 minute break.

Cyclist: A cyclist is anyone **riding** a two-wheeled pedal cycle in the observation zone on the road or the footpath.

Timing: Data are to be collected for all variables including timing (if possible) for all cyclists while they are riding in the observation zone. Stop timing if the cyclist dismounts and resume timing if the cyclist remounts while in the zone.

Footpath cyclists who cross an intersection and remount the footpath are timed as **continual footpath cycling**. However, an intersection **road entry** is recorded. Timing and coding for other footpath to road entries are described on the attachment overleaf.

If one or more cyclists enter the observation zone while timing of a previous cyclist is still in progress, all other variables (apart from timing) should be recorded if possible. At a minimum, the age, sex and helmet wearing (shaded on the data collection form) details of each cyclist entering the observation zone should be recorded.

Road entry: If a cyclist crosses the road, record whether this occurs at the intersection or mid-block. A mid-block road entry occurs when the cyclist moves from the footpath to the road; **not** from the road to the footpath.

Age: Record estimated age as a single figure, not a range.

Helmet worn: Record **yes** if cyclist is wearing a protective helmet of any type.

Helmet done: Record **yes** if the helmet chin straps are done up

Helmet carried: Record **yes** if the cyclist is not wearing a helmet but the helmet is clearly visible, e.g. held in the hand or carried on the bicycle handle-bars.

Helmet type (see helmet identification sheets):

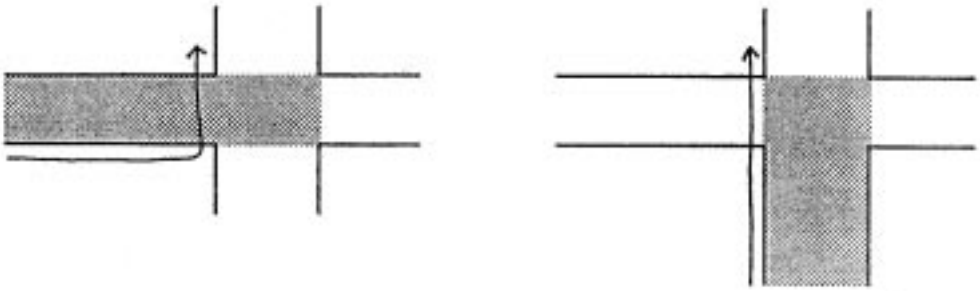
1. **Hard-shell** - hard plastic outer shell over foam lining, usually bulkier than the foam-only type.

2. **Foam-only** - have no shell and consist solely of compressed foam which is usually painted or covered with thin lycra material. Also included in this category are those helmets which have a thin and lightweight plastic shell (see identification chart).

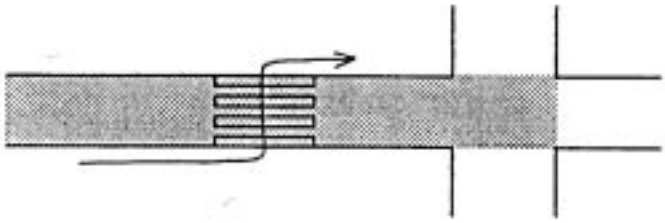
3. **Other** - any other non-regulation helmet (e.g. leather cycle racing helmet, horse-riding helmet, construction helmet).

Timing & Coding
for footpath cyclists entering the roadway

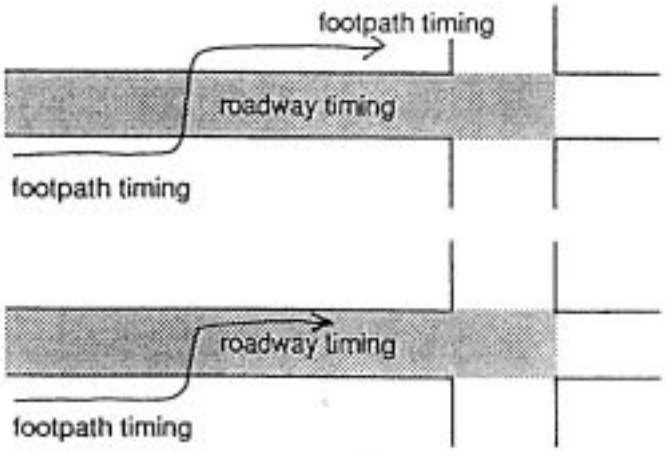
A. Footpath cyclists who cross an intersection and remount the footpath are timed as continual footpath cycling. However, an intersection road entry is recorded.



B. Footpath cyclists who cross a road at a mid-block marked, signalised, flagged or manned crossing without dismounting, are timed as continual footpath cycling. However, mid-block road entry is recorded.



C. Footpath cyclists who enter the roadway mid-block where there is no marked crossing, (even if only to to cross the road and remount the footpath) should be timed for roadway cycling for the period that they are on the road and a mid-block road entry recorded.



APPENDIX 6
SUMMARY OF OBSERVERS' REPORTS
De-briefing Session

This Appendix summarises the results from a questionnaire distributed at a de-briefing session held on Wednesday, 12th June, 1991. Most observers had finished their work on the previous Friday or Saturday. Ten of the thirteen observers completed the questionnaire.

1. SITES INAPPROPRIATE FOR CYCLISTS

Site 9,	Melways Ref. 54 B9, Chester Road, Altona
	Industrial area, dead end street
Site 12,	Melways Ref. 04 G10, Arundle Road, Keilor
	Farmland, no houses nearby
Site 35,	Melways Ref. 12 D2, Collard Drive, Diamond Creek
	Rural fringe, dirt road
Site 40,	Melways Ref. 82 K12, Hallam Road North, Endeavour Hills
	Rural residential and farmland, dirt road. **NOT ARTERIAL** as defined
Site 60,	Melways Ref. 74 E4, Lady's Walk, Ferntree Gully
	A very steep and rough dirt road, no cyclists
Site 103,	Melways Ref. 92 F2, Alfred Street, Mordialloc
	Side street, only two houses, next to busy road, no cyclists
Site 104,	Melways Ref. 78 G9, Henry Street, Heatherton
	Dirt road bounded by farm and wasteland with barrier at western end preventing through traffic
Site 105,	Melways Ref. 18 J9, Tyler Street, Reservoir
	Noted because it is a very dangerous "non-arterial" residential street with a primary school and crossing at the bottom of a hill. It is a very busy one way street connecting High Street and Plenty Road that carries bus and truck traffic as well as cars and cyclists. Requires the installation of speed humps for the protection of the school children.

2. DIFFICULT SITES

Extreme Pollution

Site 6, Melways Ref. 16 G3, Pascoe Vale Road, Glenroy

Site 45, Melways Ref. 73 K4, Burwood Highway, Ferntree Gully

Site 48, Melways Ref. 51 E10, Canterbury Road, Kilsyth (day of train strike)

Site 66, Melways Ref. 44 D4, Johnston Street, Collingwood

Site 87, Melways Ref. 68 B8, North Road, Ormond

Poor Visibility

Site 26, Melways Ref. 20 G2, Grimshaw Street, Greensborough

At this point Grimshaw Street is a road cutting. The footpath is raised and hidden from view. Visibility best from footbridge but still difficult.

Site 68, Melways Ref. 67 A3, Ormond Esplanade, Elwood

A very busy road with lots of trucks so difficult to park car. Road is also divided so it is difficult to find a position where cyclists coming from either direction can be seen clearly.

Site 81, Melways Ref. 78 E2, Warrigal Road, Oakleigh South

Very heavy traffic, making it difficult to observe and time the cyclists because the heavy traffic blocked the view

3. DIFFICULTIES WITH PUBLIC OR POLICE

Site 50, 70 C7, Viewbank Road, Mt. Waverley

Site 56, 70 E2, William Street, Mt. Waverley

Site 75, 58 H10, Montague Avenue, St. Kilda East

Site 99, 80 C8, Birmingham Street, Springvale:

" ... some residents got suspicious and approached me. But once I explained what I was doing there they were very nice and polite."

Site 75, 58 H10, Montague Avenue, St. Kilda East

"For the second year in a row I encountered a particularly nosy, defensive resident and her next door neighbour. While I welcome questions re the study in general, I particularly disliked the abrasive manner of these people. I dealt with the problem (their problem) by showing the letter of authorisation and telling them I was on public property." (male)

Site 103, 92 F2, Alfred Street, Mordialloc:

" ... a couple of sleazy men (one of whom owned the house opposite) hung around and I felt uncomfortable. I was friendly but cold and eventually they got bored and went away." (female)

Site 54, 63 F8, Quixley Grove, Wantirna:

"Some builders across the road were suspicious of my presence. They thought I had some sinister motive. But after explanation they were more convinced."

Site 33, 31 G1, Law Street, Heidelberg Heights:

"I was the second person to do this site. The local people had already noticed the first person. Residents in this street got worried about their kids, but they didn't come to see me until 15 minutes before I finished. I explained the survey, showed them the official letter and left the phone number in case they wanted to find out more." (male)

In this case a woman did ring one of the survey supervisors to enquire further. She was annoyed and concerned that the residents had not been advised about the survey.

Site 10, 27 C6, Monmouth Street, Avondale Heights

Site 23, 26 C6, Glenmaggie Drive, St. Albans South

"Some residents were just curious about what I was doing. After I explained to them, they seemed to be satisfied."

Site 62, 34 A8, Tucker's Road, Templestowe (near Primary School)

"Suspicious parents and teachers near primary schools. Informed principal."

"Public and police seemed happy once shown letter of authority and you explained what you were doing." (female)

4. CYCLISTS STOPPED AT TRAFFIC LIGHTS

All observers reported that they only timed a cyclist if he/she was moving. However, there were occasions where a cyclist would be stopped for some time while in the observation zone especially at signalised intersections. The sites listed below are those where this occurred. The column on the right indicates whether the cyclist was likely to be on the road or the footpath while stopped.

Site 1,	40 G3, Graham Street South, Sunshine	FOOTPATH
Site 6,	16 G3, Pascoe Vale Road, Glenroy	FOOTPATH
Site 25,	45 K2, Kilby Road, Kew East	
Site 26,	20 G2 Grimshaw Street, Greensborough	ROAD
Site 29,	30 H11, Victoria Road, Northcote	ROAD
Site 45,	73 K4, Burwood Highway, Ferntree Gully	ROAD
Site 48,	51 E10, Canterbury Road, Kilsyth	ROAD

Site 68,	67 A3, Ormond Esplanade, Elwood	ROAD
Site 81,	78 E2, Warrigal Road, Oakleigh South	BOTH
Site 83,	90 F7, Stud Road, Dandenong	ROAD
Site 87,	68 B8, North Road, Ormond	ROAD
Site 47,	36 H12, Plymouth Road, Croydon Hills	ROAD
	(??? school crossing not traffic lights. However, not shown in Melways No. 20 as signalised).	
Site 42,	73 B11, Kellett's Road, Rowville	ROAD
	(??? no lights but roundabout)	

5. DISCRIMINATION OF HELMET TYPE

Seven of the ten observers reported some difficulty in discriminating between hard-shell and foam-only helmets. The existence of thin-shell helmets which, for the purposes of this survey, were coded as foam-only helmets, exacerbated this problem.

6. LEVEL OF TRAINING

All respondents reported that they felt the level of training was adequate for the task. However, half thought that a bit more explanation may have helped particularly in relation to helmet typing (and also road entry judging by the initial difficulties with this concept).

7. LEVEL OF SUPERVISION

All respondents felt that the level of supervision was adequate for the task. Two thought that a bit more supervision would have helped.

8. SUGGESTIONS

Most suggestions (3) related to the appropriateness of sites for actually observing cyclists. The other related to training: take the observers outside to time cyclists and evaluate the requirements of the survey rather than watching a video!

APPENDIX 7
HELMET WEARING RATES FOR BICYCLISTS ENGAGED IN ROAD OR FOOTPATH BICYCLING ACCORDING TO ROAD CLASS

Figure 7.1

HELMET WEARING RATES IN FOOTPATH BICYCLISTS OBSERVED IN ARTERIAL ZONES
(not available for adults in 1990)

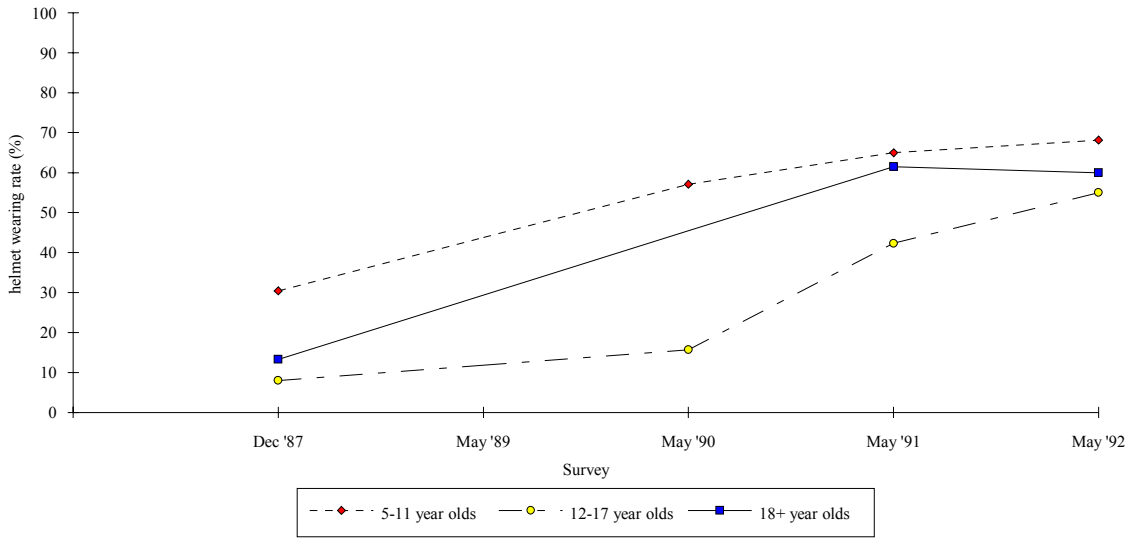


Figure7.2

HELMET WEARING RATES IN FOOTPATH BICYCLISTS OBSERVED IN NON ARTERIAL ZONES
(not available for adults in 1990)

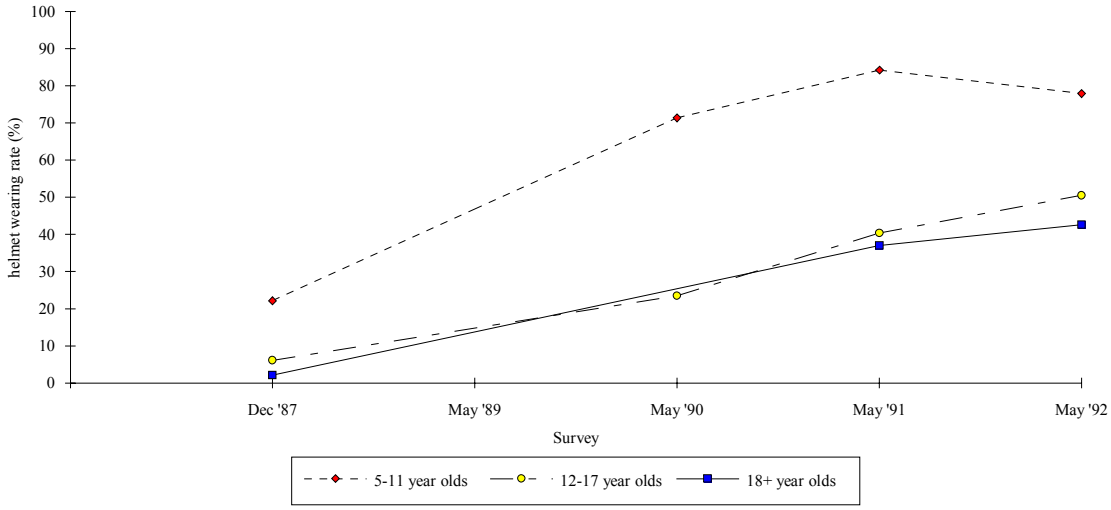


Figure 7.3

HELMET WEARING RATES IN ROAD BICYCLISTS OBSERVED IN ARTERIAL ZONES
(not available for adults in 1990)

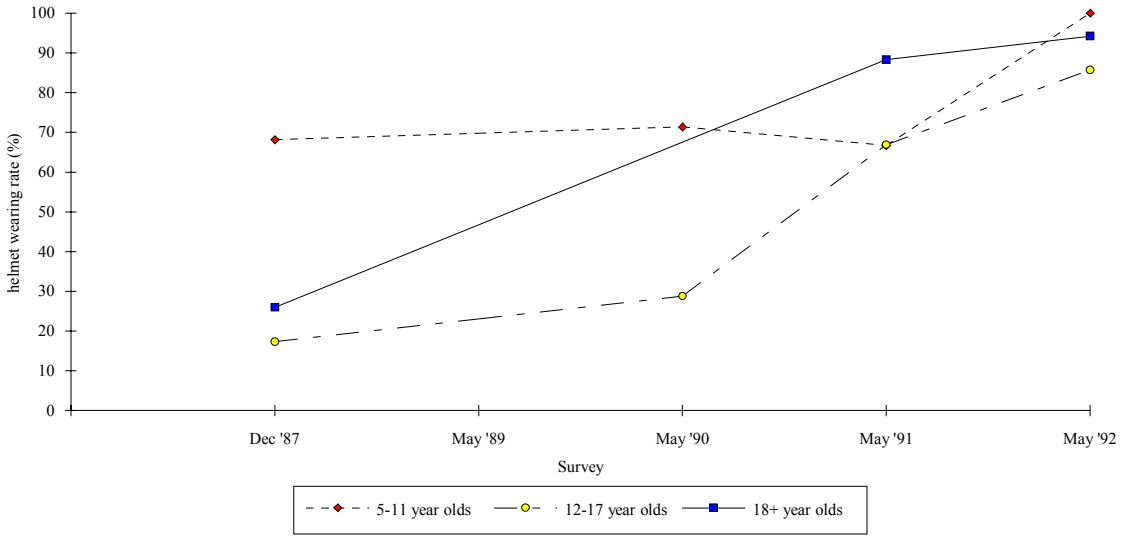
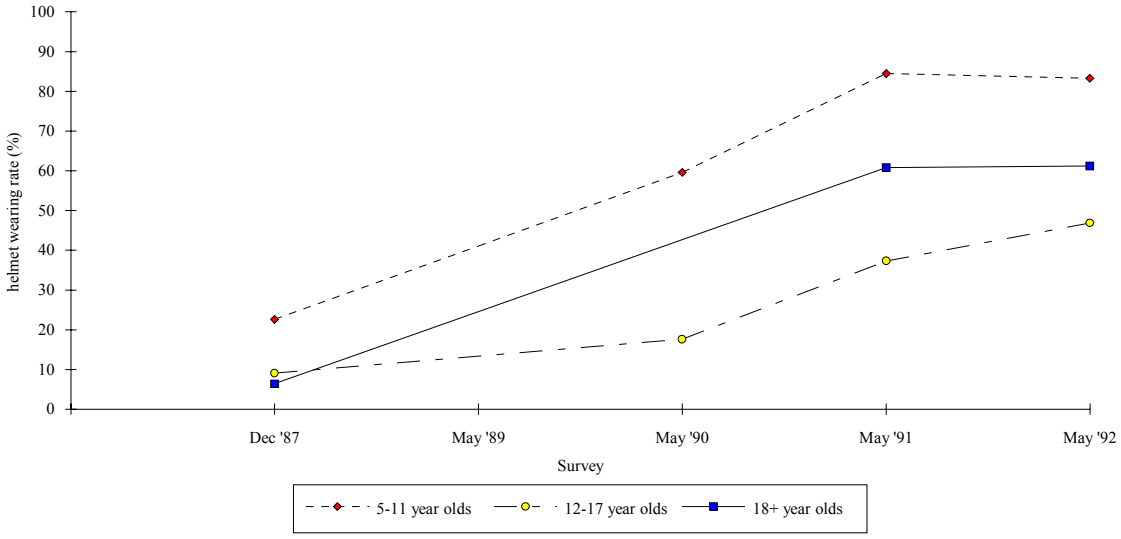


Figure 7.4

HELMET WEARING RATES IN ROAD BICYCLISTS OBSERVED IN NON ARTERIAL ZONES
(not available for adults in 1990)



APPENDIX 8
AVERAGE PROPORTION OF TOTAL EXPOSURE OCCURRING ON THE ROAD OR FOOTPATH

Figure 8.1

AVERAGE PERCENT OF TOTAL EXPOSURE OCCURING ON ROADS

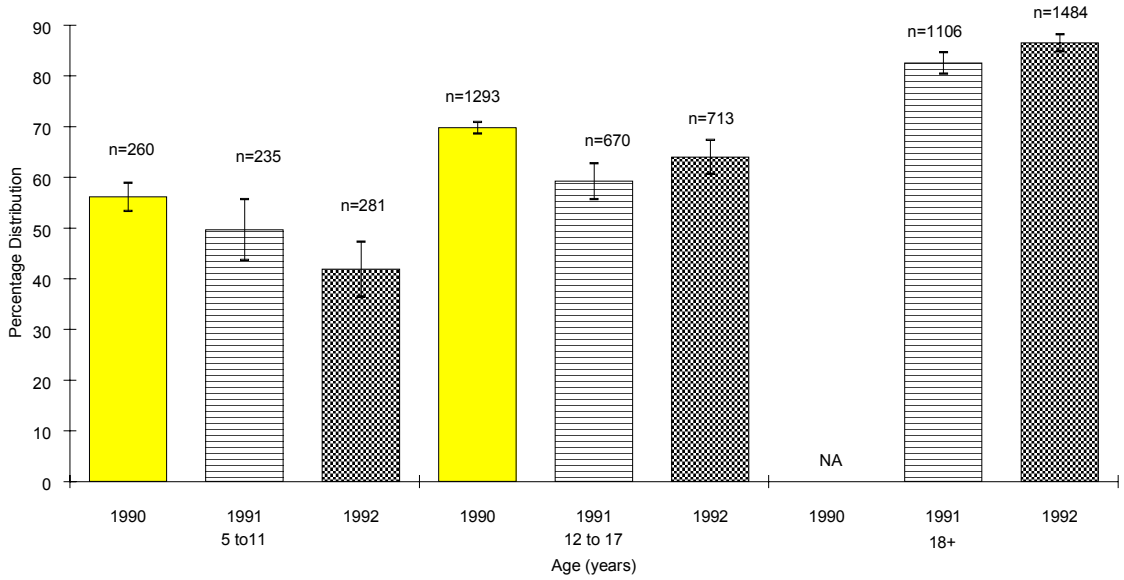


Figure 8.2

AVERAGE PERCENT OF TOTAL EXPOSURE OCCURING ON FOOTPATH ACCORDING TO AGE-GROUP AND ROADCLASS (FEMALES)

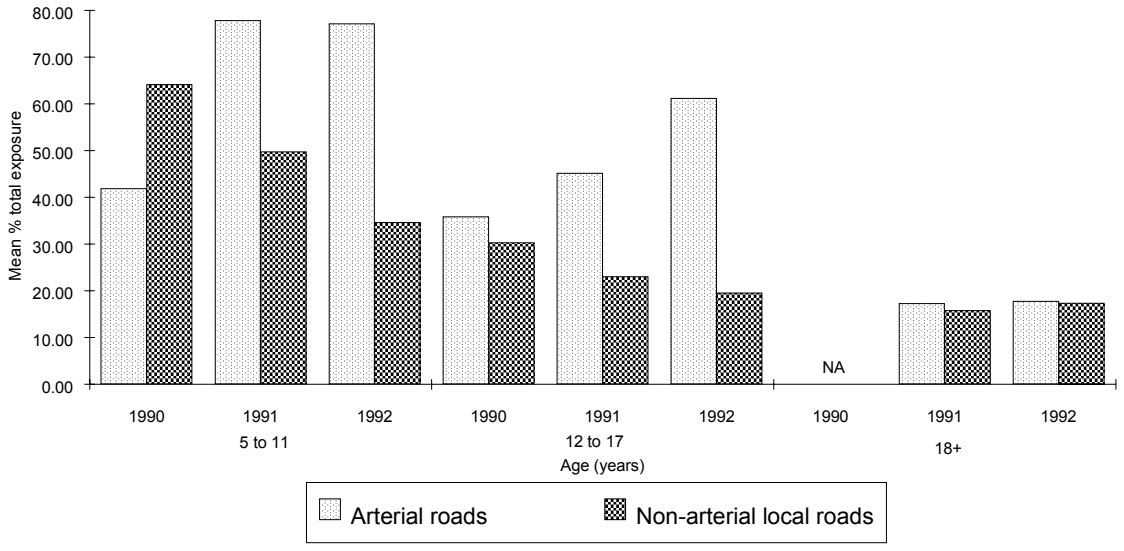
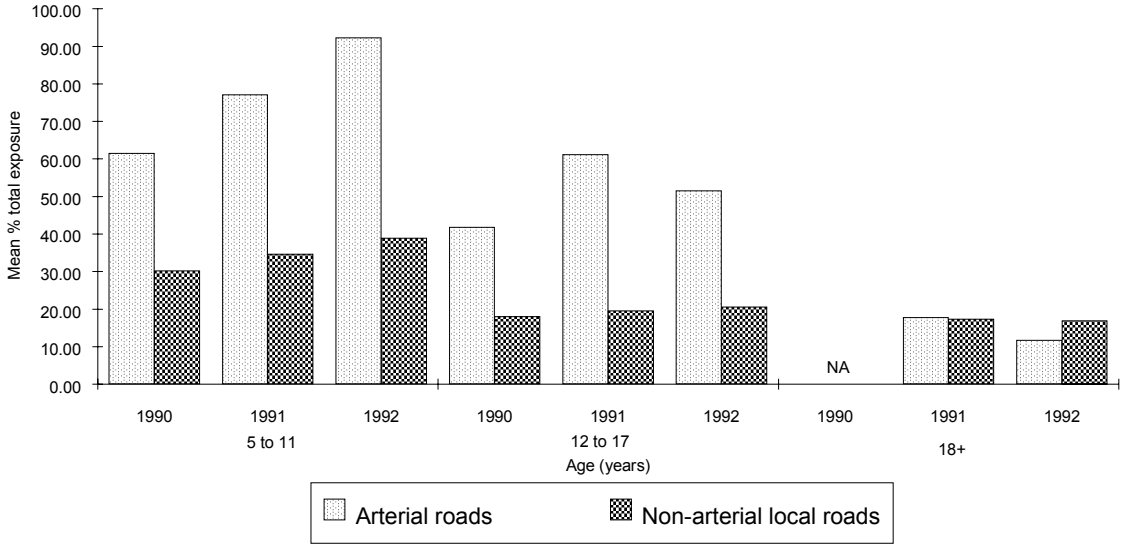


Figure 8.3

AVERAGE PERCENT OF TOTAL EXPOSURE OCCURING ON FOOTPATHS ACCORDING TO AGE-GROUP AND ROADCLASS (MALES)



APPENDIX 9
ESTIMATED TOTAL BICYCLE EXPOSURE ON THE ROAD OR FOOTPATH ACCORDING TO ROAD CLASS

Figure 9.1

ESTIMATED TOTAL BICYCLE EXPOSURE ON FOOTPATHS IN ARTERIAL ZONES IN MELBOURNE BY AGE OF CYCLIST
(not available for adults in 1990)

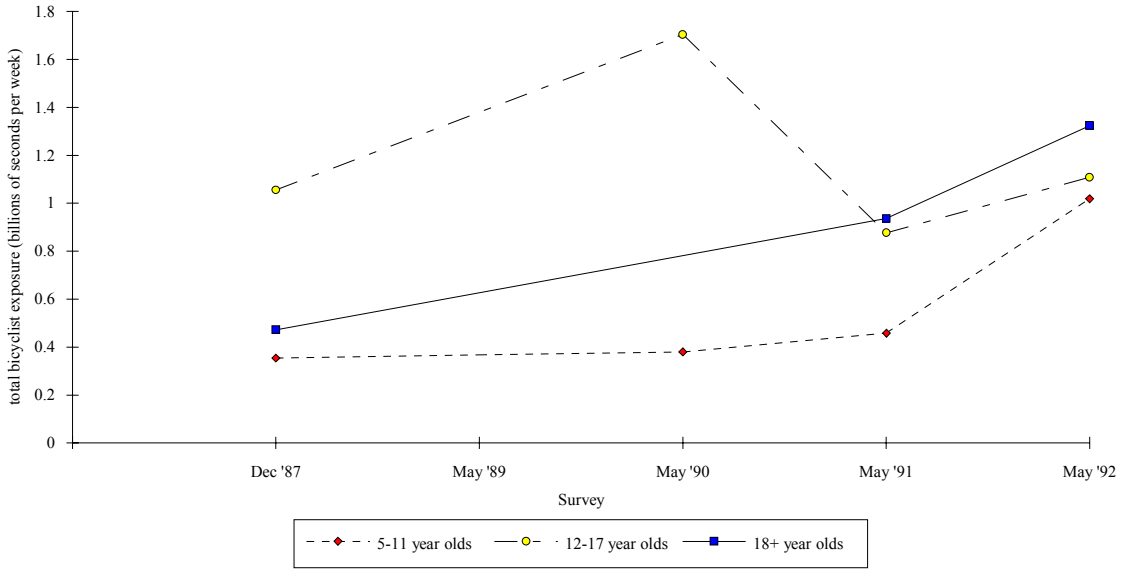


Figure 9.2

ESTIMATED TOTAL BICYCLE EXPOSURE ON FOOTPATHS IN NON ARTERIAL ZONES IN MELBOURNE BY AGE OF CYCLIST
(not available for adults in 1990)

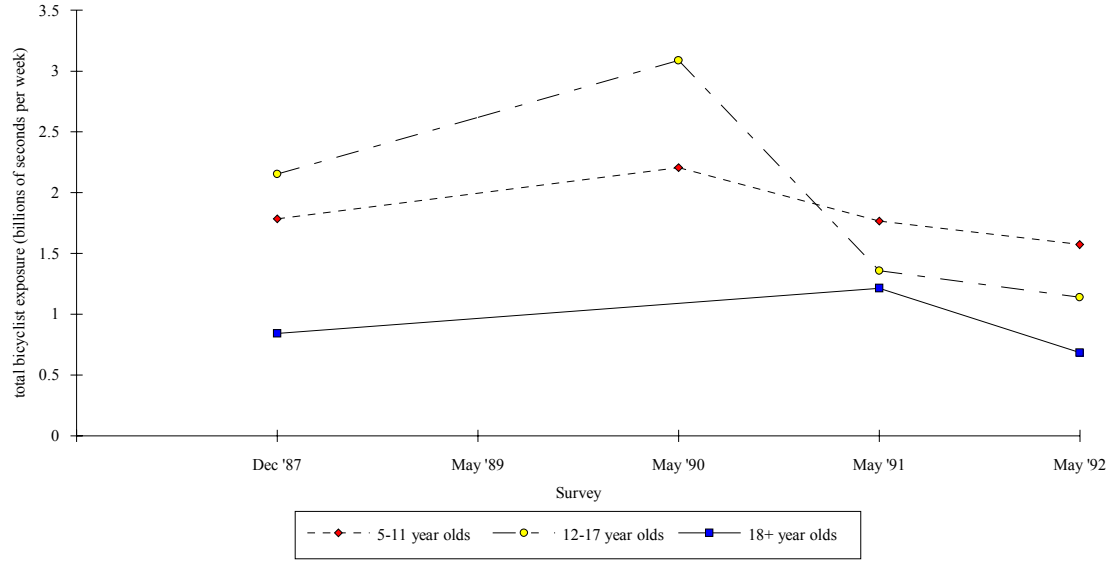


Figure 9.3

ESTIMATED TOTAL BICYCLE EXPOSURE ON ROADS IN ARTERIAL ZONES IN MELBOURNE BY AGE OF CYCLIST (not available for adults in 1990)

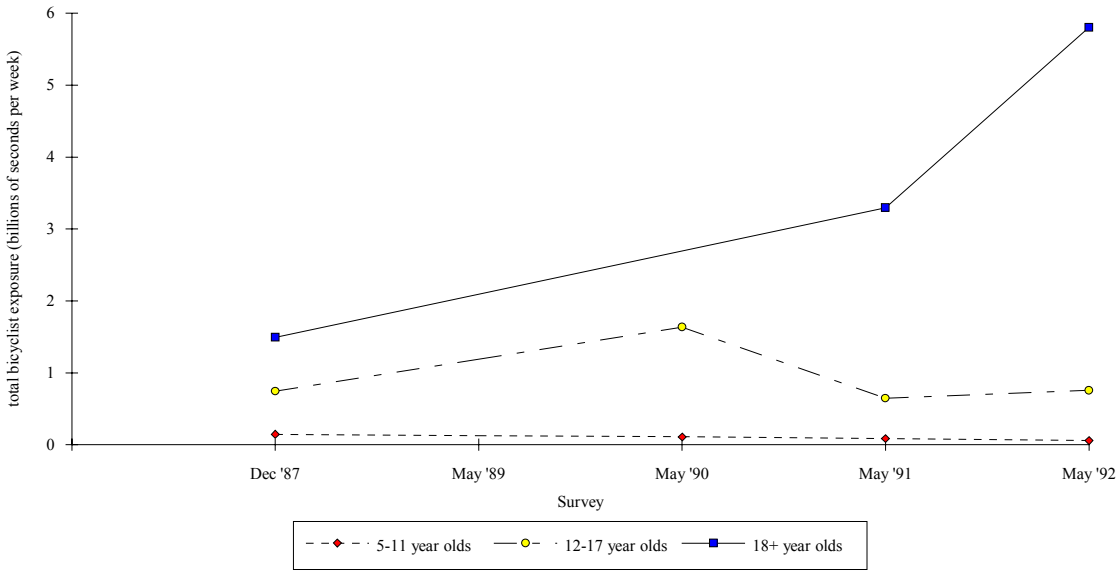


Figure 9.4

ESTIMATED TOTAL BICYCLE EXPOSURE ON ROADS IN NON ARTERIAL ZONES IN MELBOURNE BY AGE OF CYCLIST (not available for adults in 1990)