MONASH UNIVERSITY

ACCIDENT RESEARCH CENTRE

THE RISKS OF BICYCLIST ACCIDENT INVOLVEMENT

by

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October 1988

Report No. 2

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The Risks of Bicyclist Accident Involvement

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Abstract:

This report details the method and results of a study to investigate the relative safety of cycling on the road and footpath and of a variety of cycling behaviours.

A method was developed for the collection of cyclist exposure (duration of travel) and behavioural (including helmet wearing) information in 105 randomly selected observation zones in metropolitan Melbourne. Additional work was also undertaken in the area of accident data, comprising accident typology coding and an investigation of underreporting issues.

Results were provided on exposure patterns, accident involvement risk estimates and helmet wearing rates. A general interpretation of the comprehensive set of results presented in the report indicates that the safety benefits of allowing footpath cycling along arterial roads would be much greater than in the non-arterial environment. Significant improvements in the safety of footpath cycling could be accomplished if effective strategies to reduce the incidence of transitional, rideout cycling could be implemented.

Key Words:
Bicycle, cyclist, footway, accident rate, age, survey, risk, exposure, Victoria, crash helmet

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EXECUTIVE SUMMARY

This report details the method and results of a study conducted by the Monash University Accident Research Centre to investigate the relative safety of cycling on the road and footpath and of a variety of different cycling behaviours. The study was commissioned by the Road Traffic Authority and the State Bicycle Committee.

The study was initiated to provide an empirical basis for policy decisions on the possible legalisation of footpath cycling for specific cyclist groups and /or specific locations. At the same time, additional information was collected which would enable the risk of various behaviours to be estimated, thus providing the capacity for further improvements in cycling safety.

A method was developed for the collection of cyclist exposure (duration of travel) and behavioural (including helmet wearing) information in 105 randomly selected observation zones in metropolitan Melbourne. These sample data were then scaled up to the entire study area for all non-holiday periods of the year, thus providing the necessary information for the denominator of the risk ratio (an accident set divided by its comparable exposure set).

Additional work was also undertaken in the area of accident data. Firstly, to enable accident involvement risk estimates for the various behavioural classes to be calculated, typology coding was conducted (classifying accidents into accident type categories on the basis of accident report narratives and diagrams). Secondly, to counter underreporting problems, accident information was also collected directly from the hospital system. Analysis of these data demonstrated that the road/footpath risk ratio was similar for both Police reported and hospital sourced data (around 2.5 : 1) This indicates that the relative risks presented in this report are valid measures of cycling safety.

Results were provided on exposure patterns, accident involvement risk estimates of both road and footpath cycling and their interactions, accident involvement risk estimates of selected behavioural components and helmet wearing rates. Illustrations of the basic results are given in Figures A and B. Figure A presents the risks of accident involvement (per 100,000 hours of cycling) by road and footpath cycling overall and by road class. It shows that road cycling is a much riskier activity by a factor of 2.6 overall. On road cycling on arterial roads is three times more dangerous than cycling on the footpath in these locations; the same ratio applies on the non-arterial network.

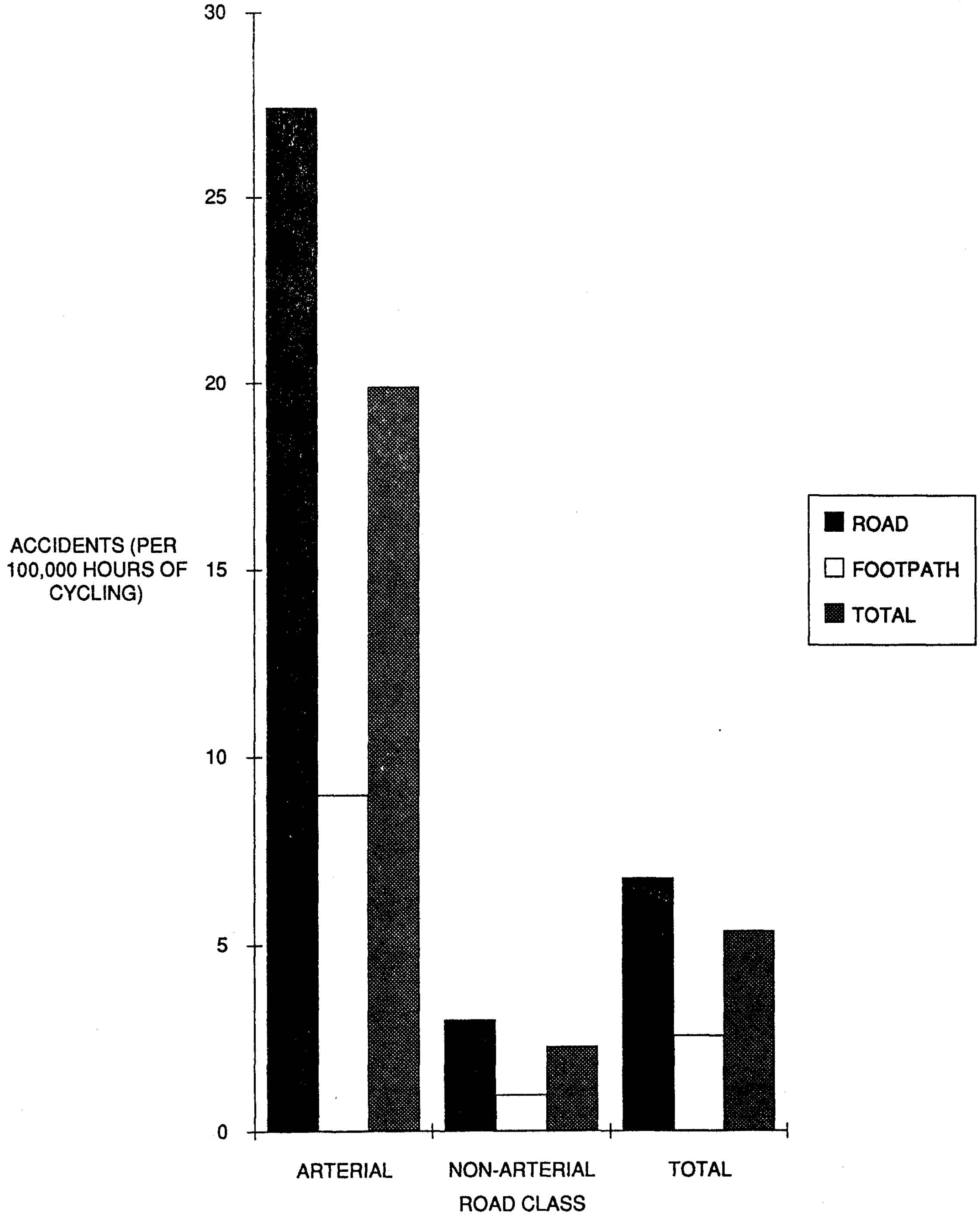

Figure A *Accident involvement risk estimates by accident type and road class*

Figure B presents the above information classified by cyclist age group. The figure shows ;

- arterial roads are the most dangerous cycling location, especially for 11-17 year olds whose risk is nearly three times greater than the other two age groups.
- footpath cycling is appreciably safer, although the improvement in safety is least for the youngest group of cyclists.
- cyclists aged 18 years or more show the smallest rate of improvement when arterial to non-arterial roads are compared by age group.

- cycling on arterial footpaths is a riskier activity than cycling on non-arterial roads (because of the enormous danger of transitional cycling, refer to Figure 17) .

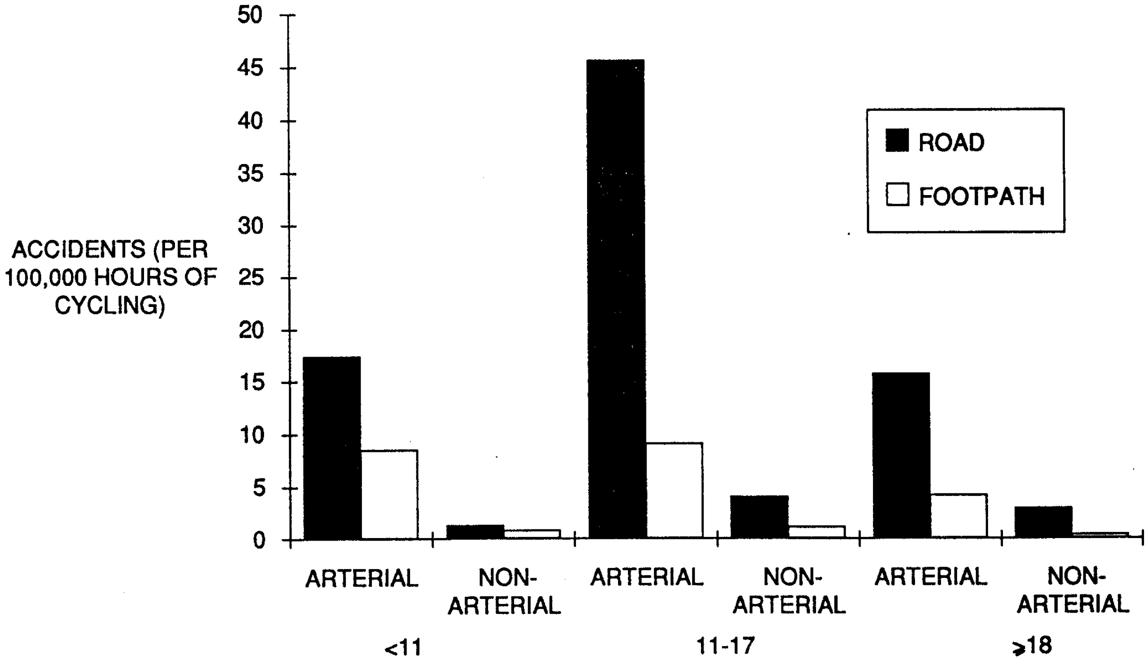

Figure B Risk estimates by accident type, age group and road class

A general interpretation of the comprehensive set of results presented in this report indicates that the safety benefits of allowing footpath cycling along arterial roads would be much greater than in the non-arterial environment. Significant improvements in the safety of footpath cycling could be accomplished if effective strategies to reduce the incidence of transitional, rideout cycling could be implemented.

THE RISKS OF BICYCLIST ACCIDENT INVOLVEMENT

1.0 INTRODUCTION

This report details the method and results of a study conducted by the Monash University Accident Research Centre to investigate the relative safety of cycling on the road and footpath and of a variety of different cycling behaviours. The study was commissioned by the Road Traffic Authority and the State Bicycle Committee.

The study was initiated to provide an empirical basis for policy decisions on the possible legalisation of footpath cycling for specific groups (e.g. young cyclists only) and/or specific locations (e.g. arterial road footpaths only). At the same time, additional information could be collected which would enable the risk of various behaviours to be estimated, thus providing the capacity for further improvements in cycling safety.

The report is set out as follows :

- Aims
- Method - the exposure survey
- Method - accident data
- Results and Discussion
- Conclusion

2.0 AIMS

The aims of the study were to;

- define the most appropriate measure(s) of cycling exposure and to design a method for collection of same
- undertake the collection of cycling exposure data
- undertake additional coding of Police reported accident data to ensure comparability with exposure data
- investigate the need for, and possible collection of, accident data from other sources to minimise the problems of under-reporting of bicycle accidents
- establish a database of comparable accident and exposure data
- estimate the risk of bicyclist accident involvement (per unit time) when cycling on the road or footpath, both at an overall level and for particular groups of cyclists on certain classes of road
- within cyclist age group/road class combinations , estimate the accident involvement risks of a range of cycling behaviours (per unit incidence) .

3.0 METHOD - THE EXPOSURE SURVEY

3.1 INTRODUCTION

Under this general heading, the following issues are detailed;

- measures of exposure
- design overview
- survey location
- sampling ratios
- sampling sites
- sampling times
- data
- pilot study
- training
- data collection
- data processing

3.2 MEASURES OF EXPOSURE

To satisfy the aims of this project, two types of measures of exposure were necessary in order to assess both the relative safety of road and footpath cycling and selected behavioural components of same. Further, these measures were such that indirect methods for their collection (e.g. interview or questionnaire techniques) were not considered as satisfactory.

While the concept of exposure has been given a variety of interpretations in the road safety literature, it is usually operationally defined in terms of either distance or duration of travel (recognising that exposure episodes may have varying degrees of actual accident risk per unit distance or per unit time). Unlike car-based exposure where distance travelled tends to be the preferred accident rate criterion, the nature of cycling exposure, especially on the non-arterial road network, requires that duration of travel is used. This approach enables more reliable data to be collected when cycling takes the second form shown in Figure 1.

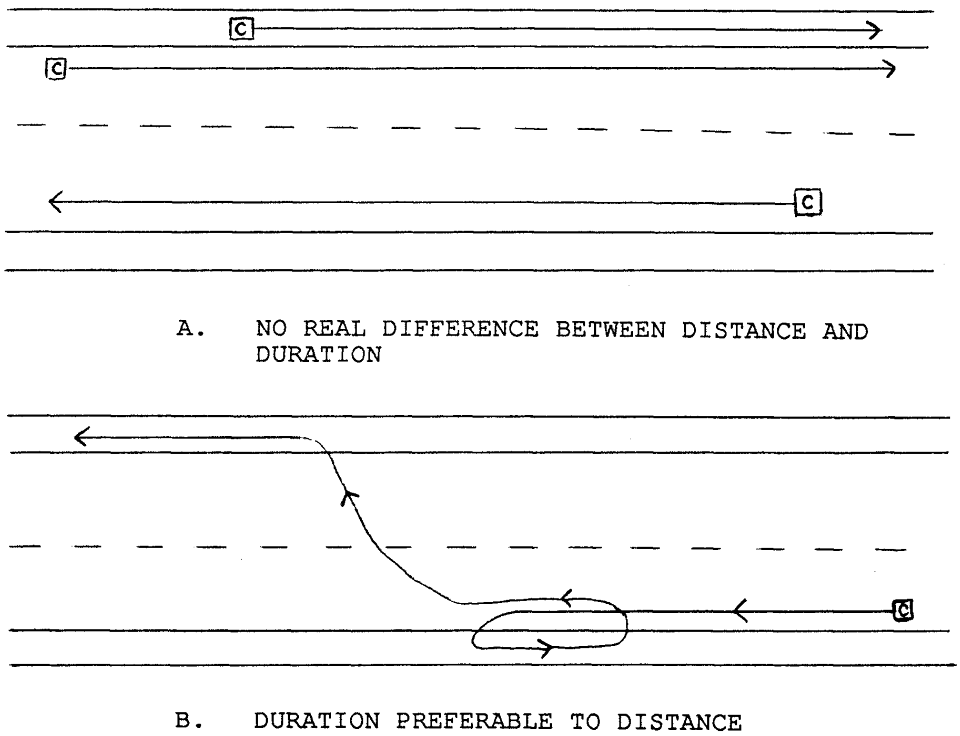

Figure 1 Exposure measures applied to two basic types of cycling behaivour

While travel speeds were not collected and an empirical link established between risk estimates (per unit time) and estimates per unit distance, it can be reasonably assumed, given the broad age groups, broad location categories and diverse types of cycling that risk estimates (per unit distance) would approximate to the risks per unit time reported.

The second type of exposure measure was required in order to establish the risk of a variety of cycling behaviours.

Such a process required the definition of six (subsequently seven) behavioural classes, each of which determined the specific exposure measure. Thus, for example, the exposure! measure for the behaviour of cycling across driveways while on the footpath (for the accident subset of colliding with vehicles backing out) was a count of the number of driveways crossed. These measures are defined in detail in section 3. 8.

3.3 DESIGN OVERVIEW

The design process involved the following steps:

- what area of the State demonstrates the greatest density of bicycle accidents and will provide the best compromise between productivity and the ability to generalise the results?
- are there any parts of this area which should be deleted for one reason or another?
- are there regions within this area which show different accident frequencies or could be expected to reflect different cycling patterns either directly or indirectly through demographic or other factors ?

- within these regions, what are the (practical) strata within which sampling should take place, in order to refine overall estimates for a given amount of' sampling?
- what allocation of total sampling time to the various strata is the most effective and efficient?

3.4 SURVEY LOCATION

Accident data analysis, together with other considerations, indicated that the study area should be confined to that shown in Figure 2 as;

- over two-thirds of accident involved cyclists were involved in accidents in the Melbourne Statistical Division (MSD)
- very few of these involvements occurred in the outer Local Government Areas (LGAs) of the MSD; they were therefore deleted
- while the LGA of Melbourne had one of the higher accident frequencies, the exposure pattern contributing to this result was considered to be at typical of other LGAs (e . g. due to pedestrian density, 'commercial' cycling, enforcement levels etc) and it was also deleted from the study area

LGAs in the areas shown in Figure 2 were assigned to one of five regions, initially for very general reasons; arterial and non-arterial road lengths (supplied by the Road Construction Authority) and accident rates per kilometre of road within each region supported the original classification.

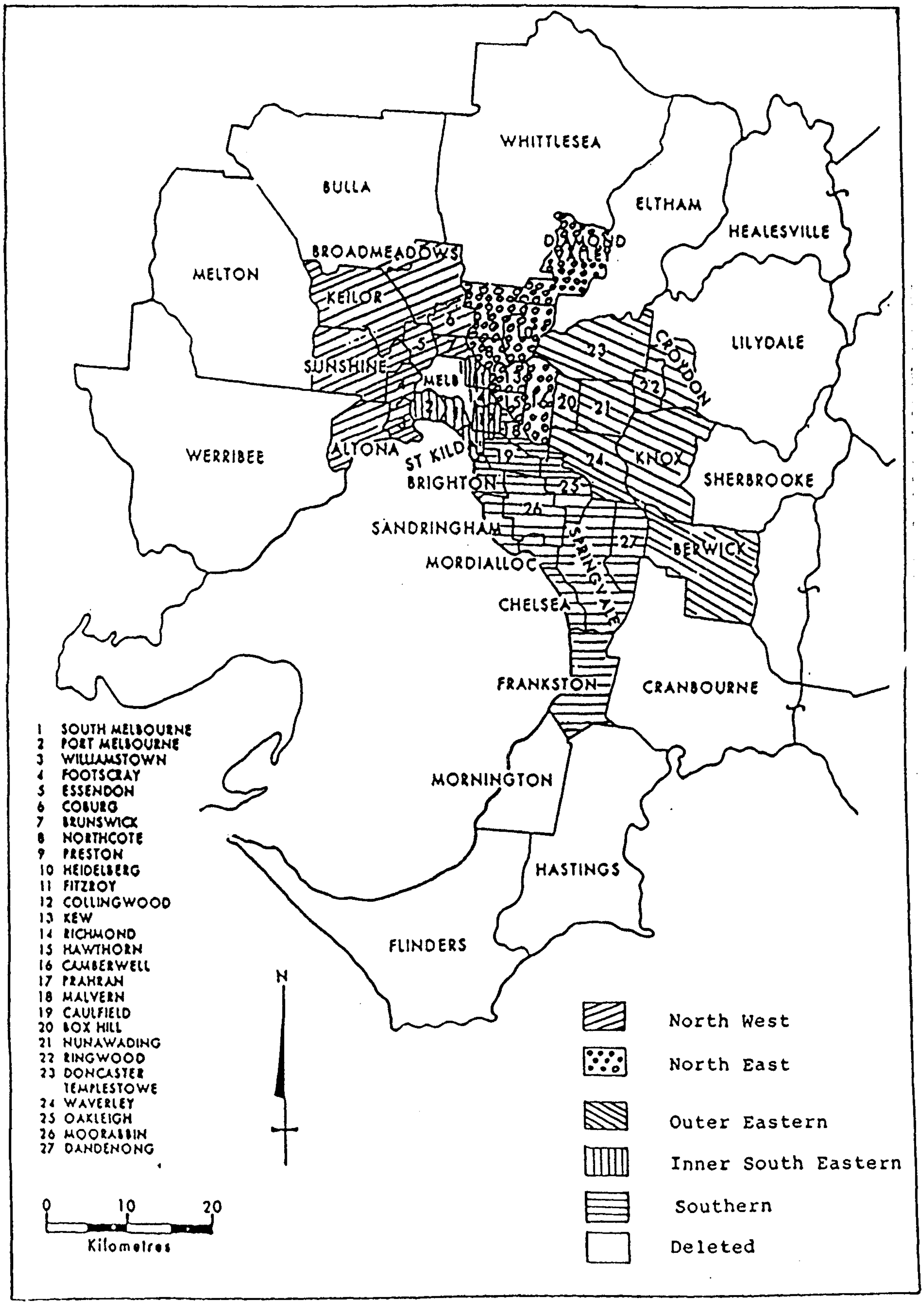

Figure 2 Exposure study area

3.5 SAMPLING RATIOS

The allocation of sampling sites between arterial and non-arterial roads presented a philosophical problem as Table 1 below shows.

Table 1 Arterial/Non-Arterial Ratios

	Arterial		Non-arterial
Road length	1	:	6
Accidents	3	:	1

If the sole aim of the study were to obtain the best estimate of total cyclist exposure, then allocation should have been in proportion to the total length of each class of road in the study area (i.e. 1:6). As the primary aim was, however, to provide exposure information for accident reduction rather than as an end in itself, Table 1 indicates that oversampling of arterial roads is appropriate. Consequently, arteria]. roads were oversampled by a factor of about 4 i.e. a ratio of arterial to non-arterial sites of about 2 3 (such a strategy was expected to generate similar numbers of cyclists on each of the two road classes).

Once this issue had been resolved, sites were allocated to regions on the basis of their proportion of the total road network length and then split into the defined road class proportions. However, due "to the relatively higher accident rate but much lower road length proportion in the Inner South Eastern region, this region was oversampled by a factor of 2.

Individual sampling sites were chosen through stratified random sampling with region forming the first stratum. Within region stratification was Limited 1:o road class as it is known that the accident profile varies by road class (Alexander and Wood, 1985), as presumably do cycling patterns and type of cyclist.

3.6 SAMPLING SITES

The conceptual basis of this survey was very similar to the on-road driver exposure surveys conducted in the metropolitan area by the Road Traffic Authority (see Drummond and Healy, 1986). The road network was conceptualised as a finite series of observation zones, from which sampling sites were selected at random. A detailed description of the site selection process is given in Appendix 1.

A sampling site (observation zone) was defined as:

> "a length of road stretching from the far side! of the selected intersection (if applicable) to a pre-determined boundary (contingent upon site geometry)".

On arterial roads, the site observation zone always started from the far side of the selected intersection and along the assigned direction. This also applied to non-arterial roads except when the intersection was formed by an arterial and non-arterial road. In these cases, the zone began where the non-arterial road ended at the intersection. In all cases, the other end of the zone was the last side street on either side of the road which could be reasonably observed from the middle of the zone. Observation zones definitions are shown diagrammatically in Figure 3.

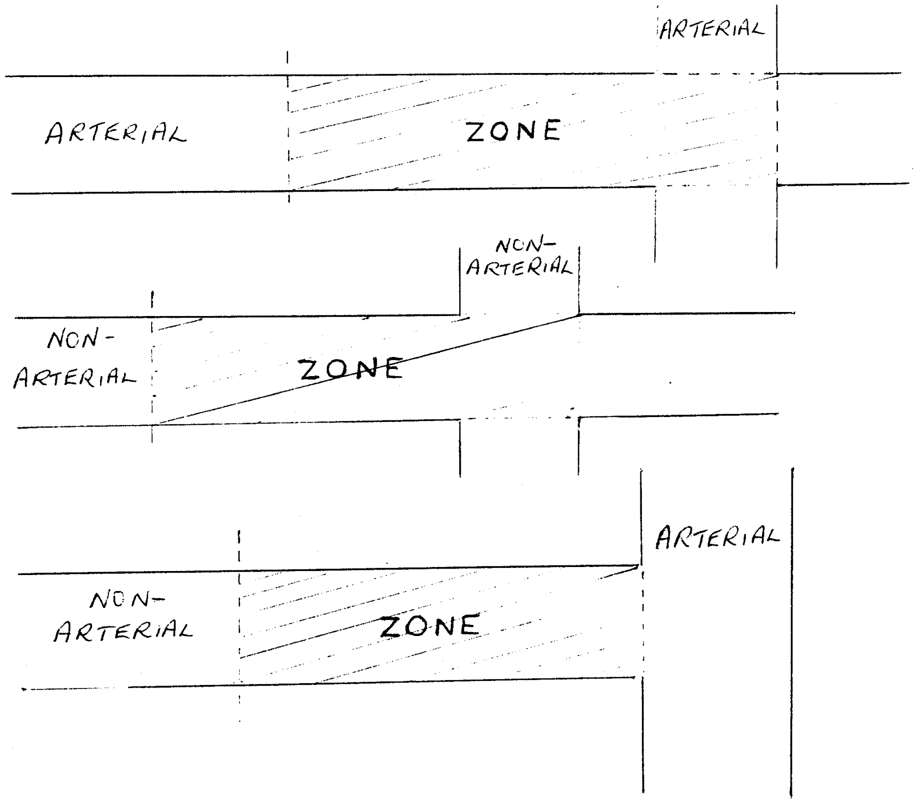

Figure 3 Observation zone definitions

In the main survey, there were 105 sites which were distributed across regions and road classes in the following way;

	REGION					
	NW	NE	OE	ISE	S	TOTAL
Arterial	8	6	10	6	10	40
Non-arterial	15	10	16	8	16	65
Total	23	16	26	14	26	105

It should be noted that certain areas/links were excluded from the study even though they fell within the previously defined LGAs in the study area. Such decisions were made on the basis that, given the geography of the site and its surrounds, the probability of a bicyclist being in the area was extremely low. In these cases, the length of road deleted was subtracted from the total road length for the region.

A complete list of sites is given in Appendix 2.

3.7 SAMPLING TIMES

The survey was limited to between the hours of 8.00am and 6.00pm on the basis that;

- the selected period should represent a significant proportion of accidents in the study (over 60%), but avoid the expense of sampling in low volume periods
- the selected period should represent a relatively stable cycling period throughout the year

Thus, although the 6.00-8.00pm period represented around 10% of cyclist accident involvements,- it presented difficulties for the calculation of risk estimates as assumptions would need to be made on the appropriate accident dataset to be used (i.e. in terms of accidents, what period of the year would be comparable to exposure data collected during daylight saving?).

Data were collected within eight basic time blocks as follows;

EARLY WEEKDAY MORNING (MON-TUES, 0800-1259)
EARLY WEEKDAY AFTERNOON (MON-TUES, 1300-1759)
LATE WEEKDAY MORNING (WED-FRI, 0800-1259)
LATE WEEKDAY AFTERNOON (WED-FRI, 1300-1759)
SATURDAY MORNING (0800-1259)
SATURDAY AFTERNOON (1300-1759)
SUNDAY MORNING (0800-1259)
SUNDAY AFTERNOON (1300-1759)

Sampling sessions by time block were allocated in proportion (i.e. no oversampling).

Given the time of year at which sampling was conducted, distinctions were made between non-holiday and holiday periods for subsequent weighting purposes. However, much more emphasis was placed on the non-holiday survey (1050 hours c.f. 160 hours); holiday data were collected to provide preliminary insight into changes in exposure patterns by period of year. Results in this report are therefore based almost entirely on the non-holiday period of the year (with non-holiday weekends being defined as a weekend between two non-holiday weekday weeks or a weekend immediately preceding a non-holiday weekday week).

Information on holiday cyclist exposure patterns and accident risks relating to the two regions in the study area for which these data were collected can be found in Appendix 3.

3.8 DATA

The information to be collected for each cyclist trip within the observation zone comprised:

- site number
- date
- road class
- day of week
- time block
- land use
- average hourly weather condition
- estimated age of cyclist
- sex of cyclist
- whether a bicycle helmet is being worn
- time (secs) spent cycling on road and/or footpath

- the number of pedestrians passed (when cyclist is on footpath)
- the number of other cyclists passed (when cyclist is on footpath)
- the number of driveways crossed (when cyclist is on the footpath)
- the number of side roads* crossed (when cyclist is riding on the footpath, i.e. an intersection rideout)
- the number of cars passing the cyclist (when cyclist is on the road)
- the number of side streets* passed (when cyclist is on the road)
- the number of midblock rideouts (cyclist goes from footpath to road)

*** it should be noted that side streets can comprise both major and minor roads.**

If another cyclist entered the zone when a cyclist was already being observed, summary data (age & sex) only was recorded for these cyclists (such cases were subsequently assigned average exposure measures for their age and sex group within a particular road class) . The data collection form is presented in Appendix 4.

As a means of ensuring that observers applied full concentration to the task, observations were only taken for 50 minutes in each hour of the five hour sampling sessions.

3.9 PILOT STUDY

Given the apparent complexity of the data collection task and the uncertainty over' the numbers of cyclists likely to be encountered in an average session (and hence the level of task demand placed on observers), a pilot study was conducted to facilitate planning. The pilot study involved two hour sampling sessions and was run over seven days and covered both types of road class.

Feedback from observers indicated that the survey, as proposed, could be handled by field staff with little difficulty. The data collection requirements, while initially demanding, were accommodated relatively quickly and the rate of observing cyclists was such that a five hour session could be undertaken.

The pilot study also generated a number of problems of definition and the need for clarification of a range of data variables .

3.10 TRAINING

A field staff of 15 was assembled to undertake the data collection phase, comprising mostly undergraduate and postgraduate students from Monash University. A comprehensive training session was conducted, involving detailed written instructions and an extensive verbal briefing. The training session concluded with a series of practical demonstrations in which the team observed and recorded the cycling behaviour of one of the project staff. A number of run-throughs were held covering the range of circumstances likely to be encountered in the actual survey.

Emphasis was given to the fact that the results of the study depended on accurate observation, strictly in accordance with the agreed definitions a]1d during the complete time period in all sampling sessions.

3.11 DATA COLLECTION

The data collection phase is described in point form below.

- data collection was divided, into two phases, non-holiday and holiday, with 1050 and 160 hours of sampling respectively (data collected in the non-holiday survey were primarily used to calculate risk estimates; the holiday survey was undertaken to provide a preliminary indication of variations in cycling exposure between these two periods)
- each site was visited twice except for sites where, on the basis of the first visit, the nature of the site and a nil bicyclist count indicated realistically that no bicyclist would be recorded on the second visit. In these cases, .the second visit was notionally assigned a bicyclist count of zero
- every effort was made to control the quality of data collected by close supervision of field staff. They were visited regularly, especially during the early stages of the data collection phase to clarify any ambiguities in procedure and, in the later stages, to maintain interest in the task
- completed data collection forms were collected on these visits to minimise the chance of loss or damage of forms
- sessions which were not able to be done on the assigned day were rescheduled in another week within the appropriate week/time block

In all, information was collected on 5,837 cycling episodes during the exposure survey.

3.12 DATA PROCESSING

All data collection forms were sent to a data entry subcontractor where the exposure data were key punched into a data base in a format described in Appendix 5.

Survey data were then scaled up through the application of a number of weighting factors to transform information contained on each record into its annual equivalent; these values could then be summed to provide annual exposure for any sub-group of interest. This process took the following form;

- average values within region, age group and road class for observed and measured cyclists were computed for each of the nine exposure variables and assigned to the relevant observed (but not measured) cyclists
- three separate time-based weighting factors were then applied to;
  - scale the five fifty minute sampling sessions up to a full five hour period
  - scale the eight time blocks up to a standard week
  - scale this weekly exposure estimate up to an annual estimate, using either a holiday or non-holiday weighting factor
- within a time element (a five hour period within one of the eight time blocks), survey data were scaled up by the ratio of total road length (within a region and road class) to length of zone at which the data were collected
- the resultant value was then divided by the number of times that the given time element (within a region and road class) had been sampled.

All data are stored in a structured sub-directory on the RTA's VAX Cluster.

4.0 METHOD - ACCIDENT DATA

4.1 INTRODUCTION

Under this general heading, the following issues are detailed;

- overview
- problems specific to this project
- typology coding
- other data sources

4.2 OVERVIEW

The numerator of the ratios used to calculate the risk of a particular cycling behaviour is the average annual accident count for the years 1984 and 1985 in the study area and. period. These years were chosen as typology coding (see section 4.4) had already been undertaken for accident.-involved cyclists under 15 years of age.

A check was made to determine the appropriateness of this procedure, given that exposure data were collected in 1987. The results of this process are given in Appendix 6.

In the context of this study, the use of accident and exposure data drawn from different time periods is not considered to have had a major effect on the study outcomes. However, the typology coding of more recent data, preferably 1987, would be a worthwhile exercise.

4.3 PROBLEMS SPECIFIC TO THIS PROJECT

In theory, all bicyclist accidents in which at least one participant was injured (and required medical treatment) should feature on the RTA's Traffic Accident Record.

This includes both bicycle casualty accidents on the footpath (designated as part of the roadway) and need not necessarily involve a car (for reporting purposes, a bicycle is deemed to be a motor vehicle; thus, a bicycle-pedestrian collision occurring on the footpath and involving an injury should be reported).

In practice, however, it is accepted that accidents of different types are underreported; there is some evidence indicating that this is a particular problem with less severe accidents involving young unprotected road users i.e. bicyclists and pedestrians (Maas & Harris 1984). Estimates of the extent of underreporting have varied widely, ranging from 20% reported (Lugg, 1982) through 8% reported (Young & Apelbaum, 1984) to 3% reported (Geelong Bike Plan, 1978).

In this context, therefore, it was necessary to investigate ways in which such problems could be minimised. Activities in this regard are outlined in section 4.5.

4.4 TYPOLOGY CODING

To enable risk estimates for the various behavioural classes to be calculated, additional typology coding was required. This involved the application of a modified Cross and Fisher typology (Cross and Fisher, 1977) to 1984 and 1985 bicyclist involvements in casualty accidents, a process which had already been completed for cyclists; under the age of 15 years and described by Cavallo and Wood (1987).

Two postgraduate students undertook this task, initially concentrating on accidents in the study area. As the coding was done at the RTA, an experienced staff member was available to resolve coding difficulties. The range of problem types were classified into the behavioural classes observed in the exposure survey; the way in which problem types were combined is shown in Appendix 7.

4.5 OTHER DATA SOURCES

In an effort to overcome the problems outlined in the second part of this section, other data sources were investigated to determine the extent to which they could complement the Police reported accident data available from the RTA's Traffic Accident Record and therefore provide more valid (as it turns out, absolute) risk estimates.

Initially, a magnetic tape was purchased from Health Computing Services (arranged through the Health Department of Victoria) which comprised the Hospital Morbidity File for 1984 to 1986. This database covers all hospital admissions, providing statistical information on injury types and patient characteristics. While it was possible to identify the class of bicyclists injured in non-traffic motor accidents (e.g. footpath related accidents), the data did not contain sufficient information to discriminate between footpath and other non-road accidents (e.g. in parks, backyards etc.)

To overcome this problem, it was recognised that specific data collection would need to be undertaken. To this end, arrangements were made to utilise the data collection procedure initiated for Associate Professor F McDermott's study. This study was designed to provide information on the injury profile of pedal cyclist casualties wearing and not wearing a bicycle helmet. This prospective study collected data on cyclists treated at the Casualty/Emergency Departments of 10 Melbourne hospitals and the Geelong Hospital. The specific accident location details required for the current study necessitated cyclists already included in the study to be re-contacted for further information. A specific data collection form was designed for this purpose and is shown in Appendix 7; such information was made available for almost 600 relevant cyclists. The co-operation of Assoc. Professor McDermott and Sister Debney in collecting this extra information was much appreciated.

A 50% sample of these cases were compared to the RTA's database of Police reported accidents, with a matching rate of 11%. While this indicates a considerable degree of underreporting, and possibly some inability to match common accidents, the numbers are not sufficiently large to enable reliable estimates of underreporting by accident type and/or age group and/or road class to be made. Therefore, general risk estimates were calculated using both accident datasets independently (see Figure 14). Although it is not possible to determine the relationship of either dataset to the universe of cyclist accident involvements (and thus the real level of absolute risk), it is the relative risks which are of primary importance. The fact that the road/footpath risk ratio was similar for both sources of data (around 2.5:1) indicates that the relative risks presented in this report are valid measures of cycling safety.

Relative risk estimates will be affected by reporting issues to the extent that the datasets used in the analysis are non-random samples of the accident universe. There is no evidence to suggest that this aspect presents significant problems for the study.

Nevertheless, in terms of absolute risks of bicyclist accident involvement, accident data remains the weak link in the chain; further work in extending the approach initiated in the current study is recommended.

5.0 RESULTS AND DISCUSSION

5.1 INTRODUCTION

It is emphasised that results presented in this section refer to exposure patterns or accident involvement risk estimates based on non-holiday weekday and weekend exposure and accident data for the study area, unless otherwise stated.

The data used to calculate the risk estimates are contained in Appendix 8. Reference to this appendix is especially recommended when the detailed results are being reviewed as the accident numbers resulting from additional filtering are often small. As such, some of these results should be interpreted cautiously.

Appendix 3 contains some results for the holiday period for the two regions in the study area for which these data were collected. These results should be interpreted with caution due to the small numbers involved.

5.2 EXPOSURE PATTERNS

This section presents some general results on exposure patterns, using the exposure data as an end in itself. Figure 4 shows how cycling exposure on the road or footpath is split across the two road classes.

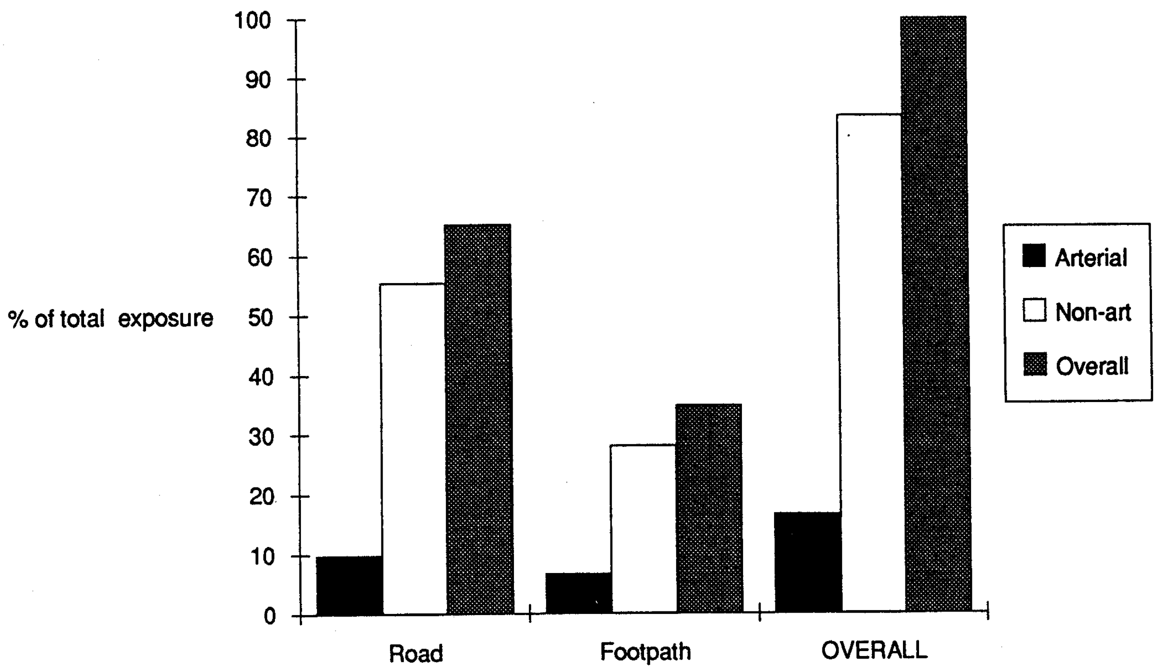

Figure 4 Cycling exposure by road/footpath and road class

The figure shows that exposure is heavily weighted towards the non-arterial network, which accounts for some 83% of total exposure. The ratio of road to footpath is between 1.5 (arterial) and 2.0 (non-arterial).

Figure 5 presents the above data broken down by age group. Figure 5 shows that less than one second in every 20 seconds cycled on arterial roads is done by cyclists under the age of

11 years on the road. Nearly fifty per cent more cycling is done on arterial roads than arterial footpaths. On arterials, the cyclist group with the greatest single amount of exposure is the 18 years and over group on the road (39.0%); indeed, this group accounts for almost 50% of cycling exposure on the arterial part of the road network.

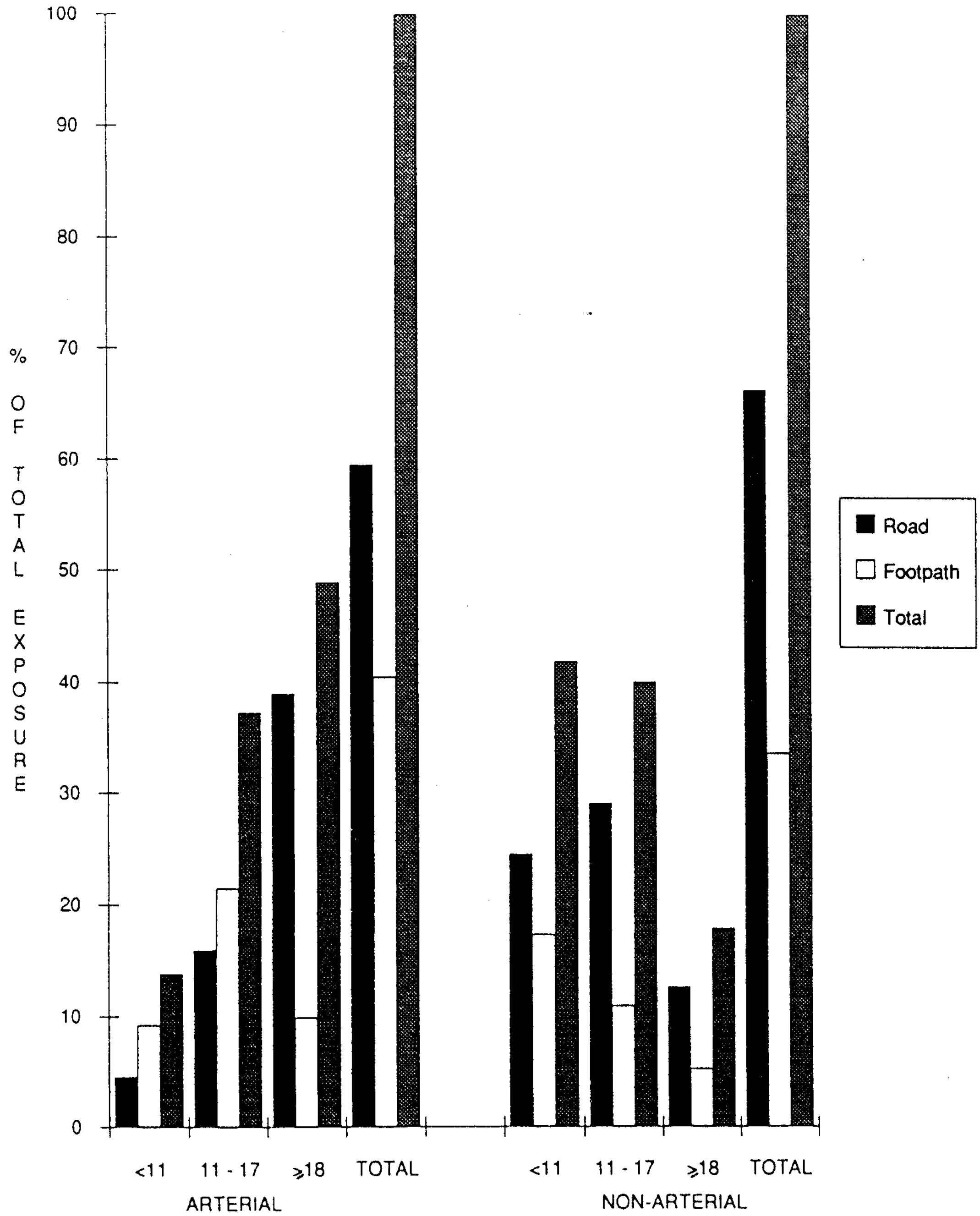

Figure 5 Cycling exposure by road class, road/footpath and age group

On the non-arterial network, however, a dramatically different exposure pattern can be seen. Cyclists under the age of 18 years account for just over 80% of total exposure. Roughly two-thirds of cycling is now done on the road (compared to just under 60% on the arterial network) with cyclists aged between 11 and 17 years contributing most to on-road exposure.

The overall result (Figure 6) demonstrates the decreasing incidence of footpath cycling with age and the major contribution that cyclists under the age of 18 years make to total exposure.

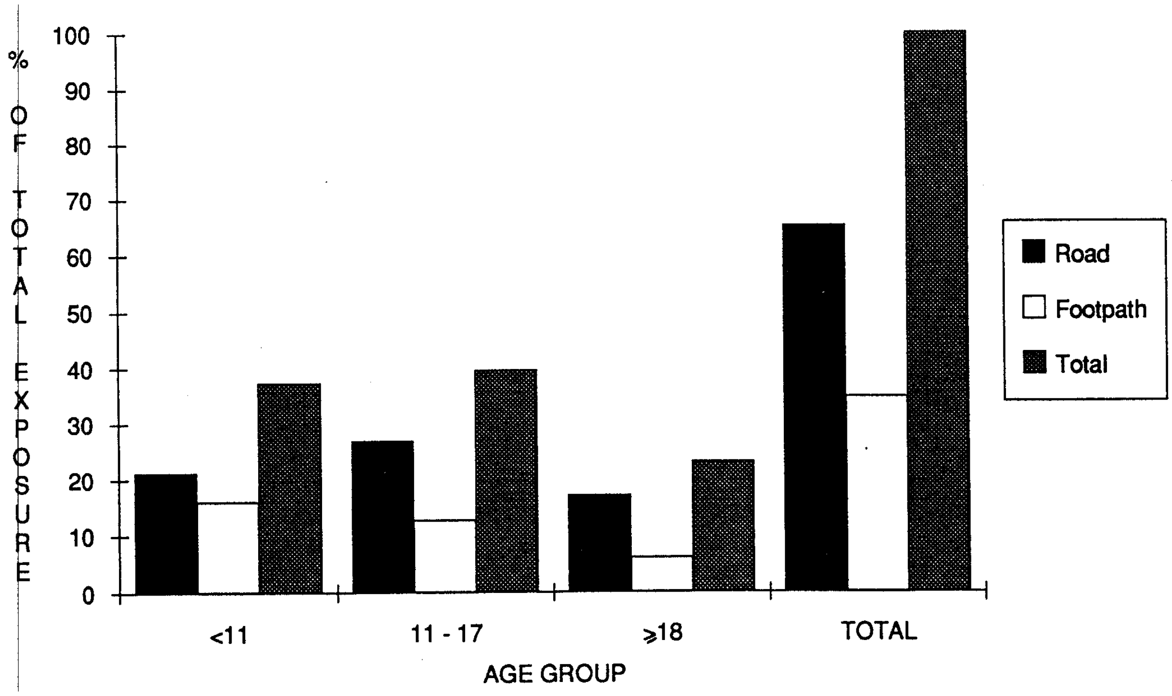

Figure 6 Cycling exposure by road/footpath and age group

Figures 7 and 8 show the effect that a weekday/weekend split has on cyclist exposure by road class and age group. Independent of road class, the figures show a consistent weekday to weekend ratio of about 2 : 1.

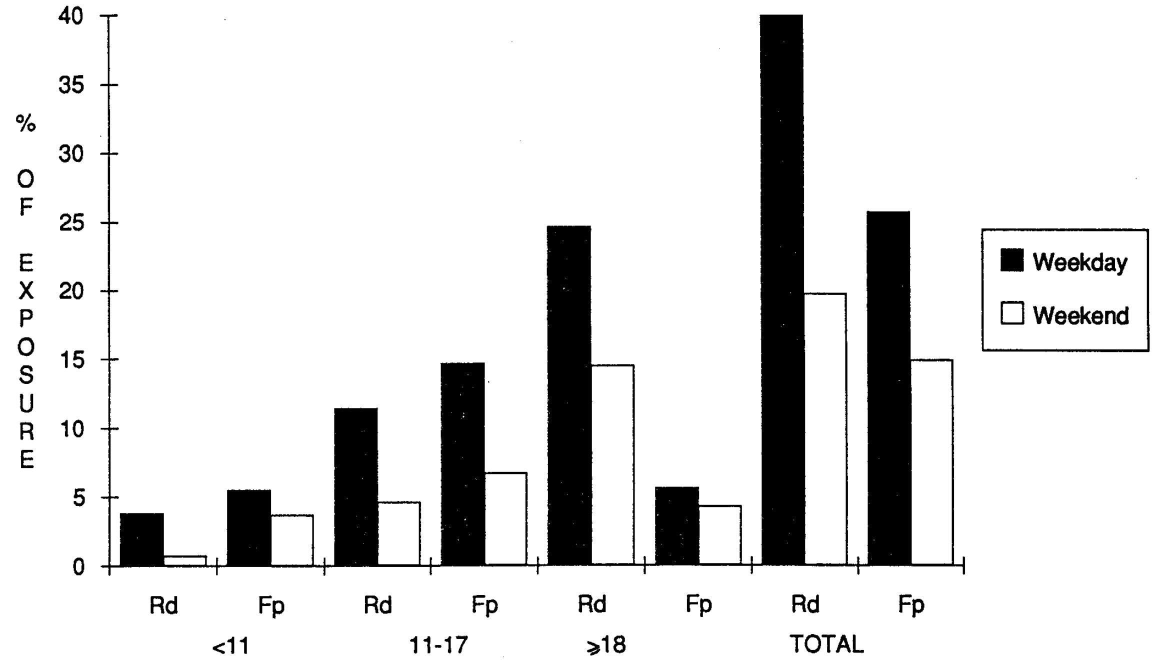

Figure 7 Arterial exposure by agegroup and weekday/weekend

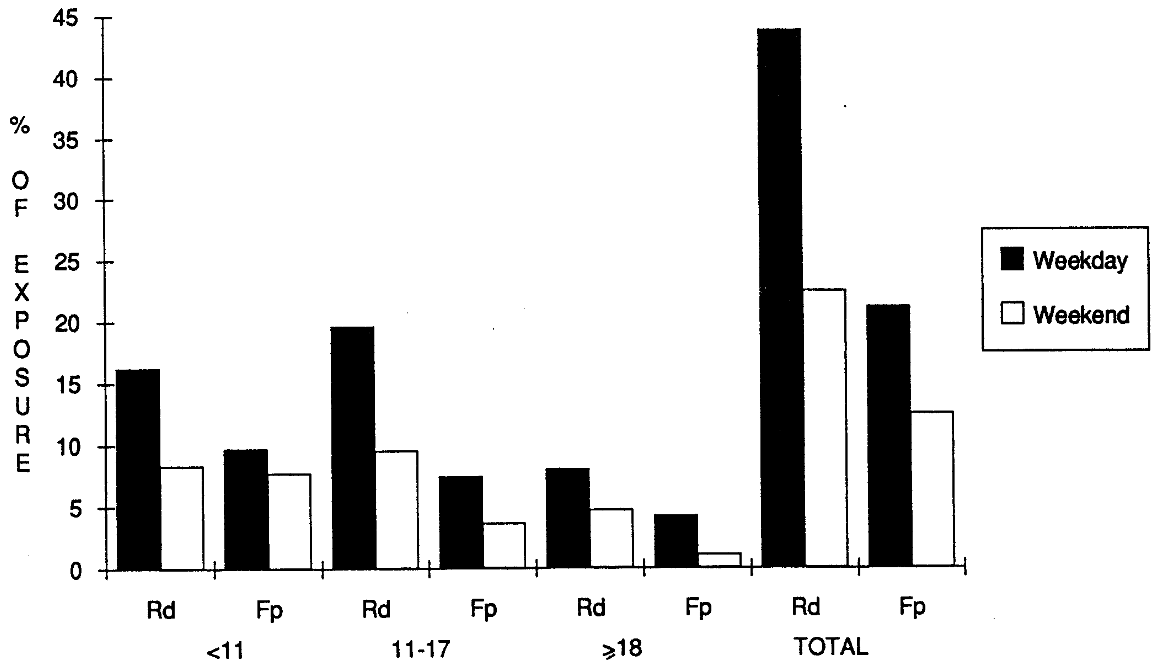

Figure 8 Non-arterial exposure by agegroup and weekday/weekend

Figure 9 plots cyclist exposure by age group and sex of cyclist for the two types of road class. It can be seen that male cyclists account for a much greater proportion of exposure (over 83%) and that this 5 : 1 ratio applies consistently across age groups and road classes. Male cyclists aged between 11 and 17 years represent the largest portion of exposure, 85% of which is manifested on the non-arterial network.

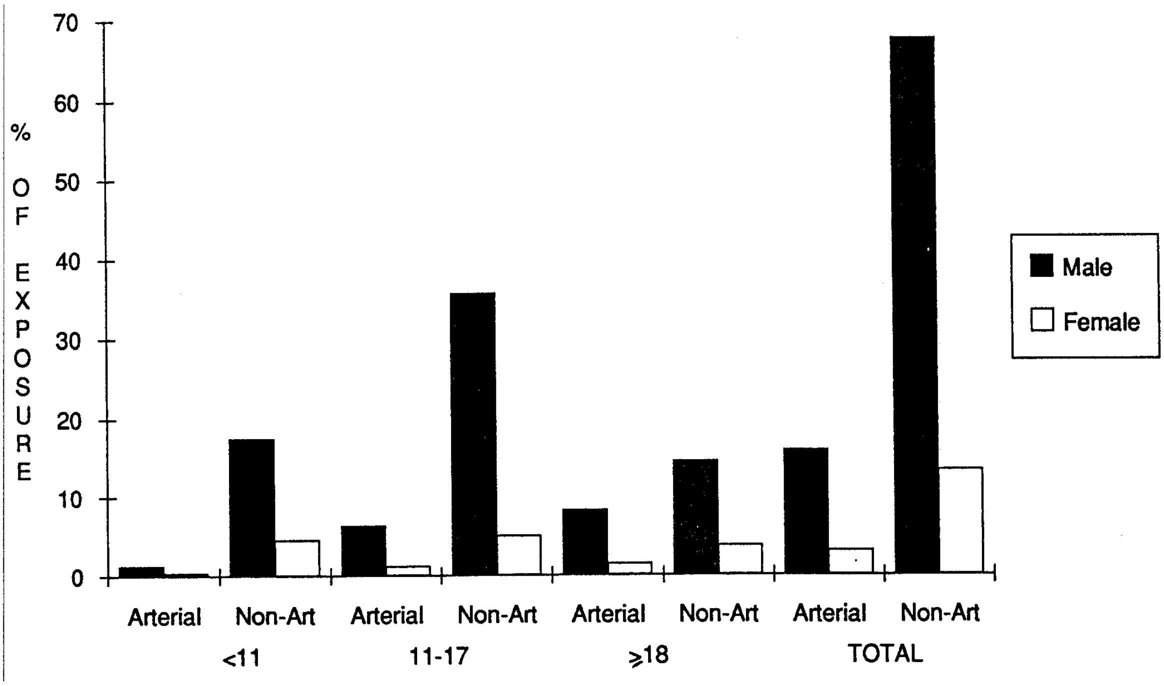

Figure 9 Cycling exposure by road class, cyclist age group and sex

The next exposure pattern to be presented in this section shows the way in which road and footpath cycling exposure varies by cyclist age group and land use. Figure 10 highlights the concentration of cycling in areas coded as primarily residential, accounting for over

76% of total exposure. Cycling in commercial areas, both on road and footpath, contributes only 2.5% (of which footpath cycling represents 46%).

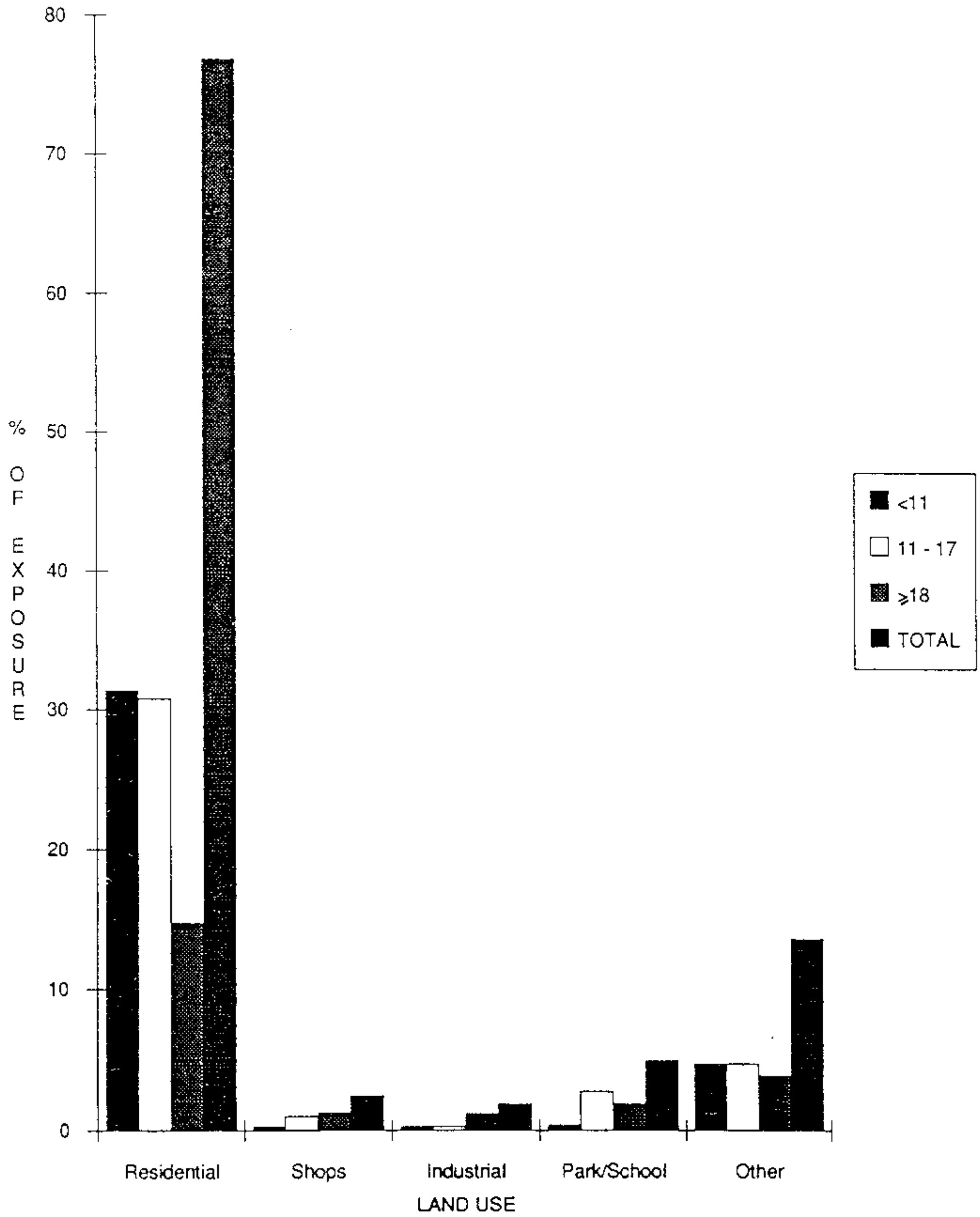

Figure 10 Cycling exposure by age group and land use

The final two figures in this section present information on pedestrian passing rates on the footpath (per kilometre of road). As noted later in this report, information on the extent of pedestrian casualties following collisions with cyclists is poor. Figures 11 and 12 are designed to place the potential for pedestrian-cyclist conflict in perspective by presenting passing rates. Figure 11 presents these rates by cyclist age group and road class, while Figure 12 classifies passing rates by cyclist age group and reported land use (estimated from sample proportions).

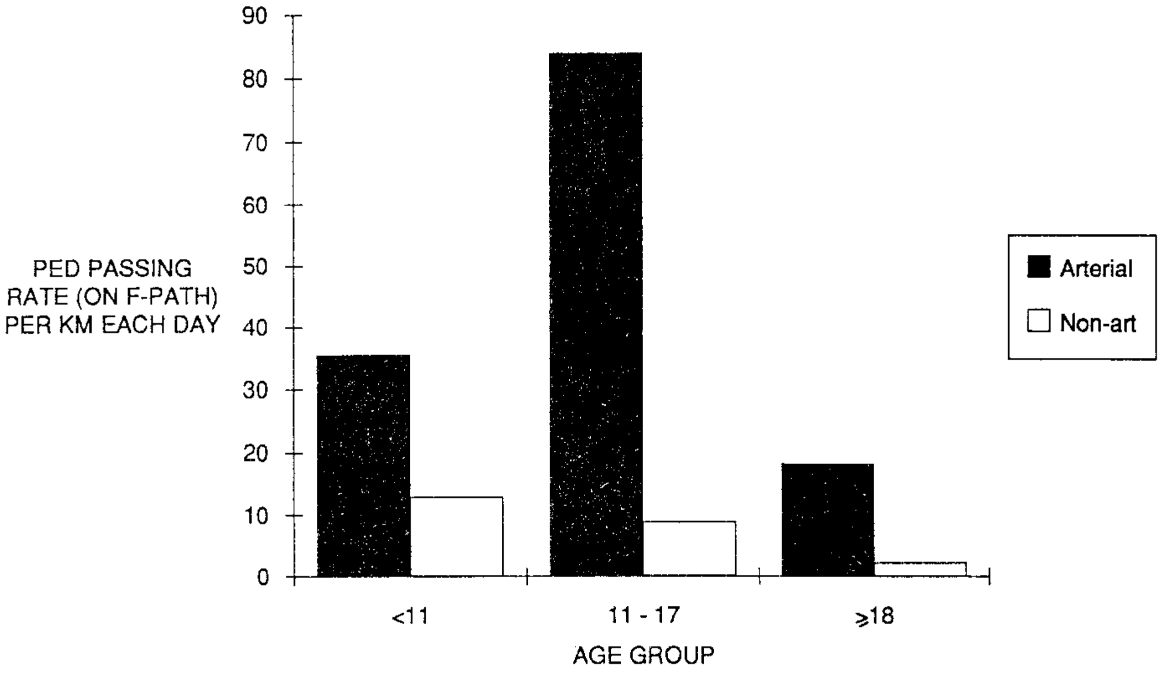

Figure 11 Daily pedestrian passing rates (per kilometre of road) by cyclist age group and road class

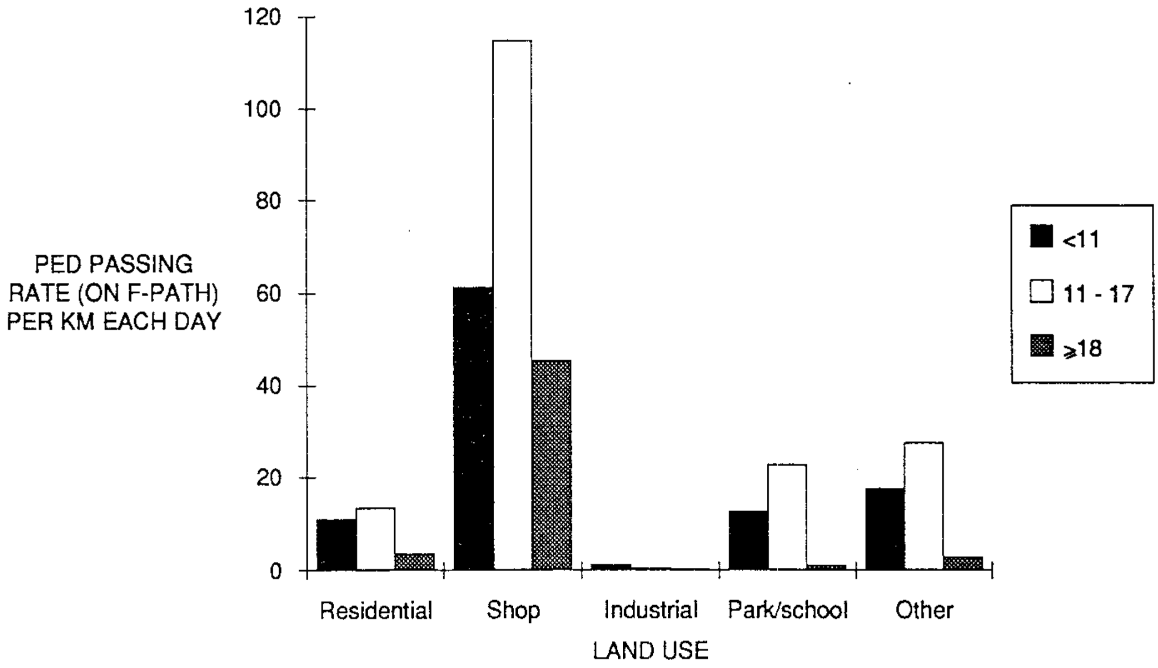

Figure 12 Daily pedestrian passing rates (per kilometre of road) by cyclist age group and land use

5.3 OVERALL RISK ESTIMATES

This section presents accident involvement risks at a general level. These risk estimates take the general form of;

$$\frac{\text{NUMBER OF CYCLISTS INVOLVED IN ACCIDENTS}}{\text{COMPARABLE EXPOSURE MEASURE}}$$

The numerator can be defined in a number of different ways, e.g. young cyclists, male cyclists, only those on arterial roads, those involving non-arterial footpaths, etc. In every case, it is essential that the comparable exposure dataset is used in order to calculate a valid risk estimate for the cyclist accident class under investigation.

Although there may be arguments against collapsing data from the three age groups and two road classes (because of the varying degrees of exposure to risk found within these six cells), this section does provide introductory results and establishes a context in which the more specific results can be viewed. It should be noted that disaggregation of accident data can lead to reasonably small numbers in the numerator of the risk ratio (refer to Appendix 8 for the data used).

Figure 13 presents the risks of accident involvement (per billion cycling seconds) by road and footpath cycling overall and by road class (it should be noted that rideout accidents are included in the risk of footpath cycling for these results; see Figure 17 for the effect on accident involvement risk of separating transitional [intersection and midblock rideouts] . cycling from straight footpath cycling). It shows that road cycling is a much riskier activity by a factor of 2.6 overall (19.0 accidents per billion seconds on the road c.f. 7.4 involving footpath cycling). On road cycling on arterial roads is three times more dangerous than cycling on the footpath in these locations; the same ratio applies on the non-arterial network.

The data also show that it is over 8 times more dangerous to ride a bicycle in an arterial environment (road or footpath) than a non-arterial environment.

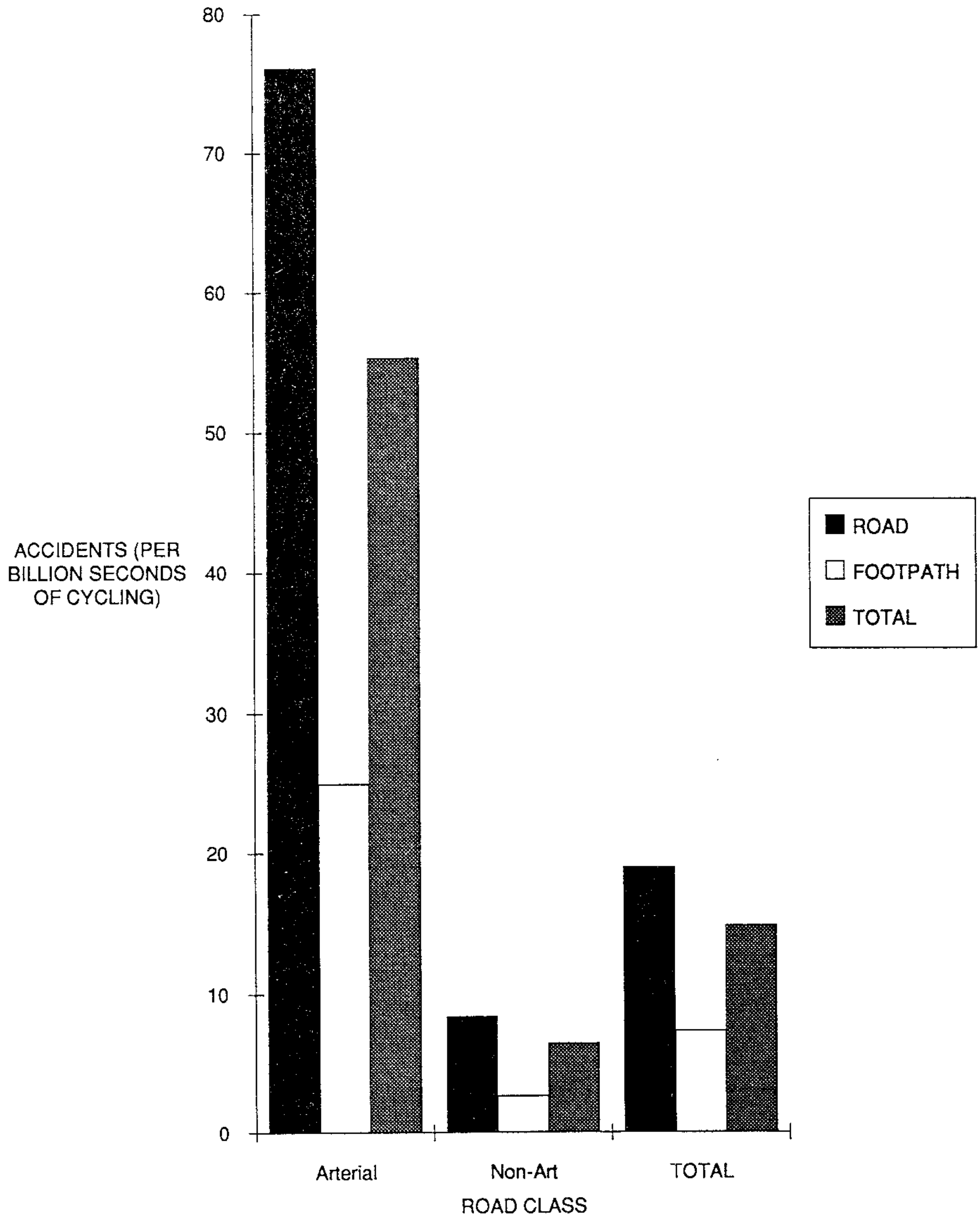

Figure 13 Accident involvement risk estimates by accident type and road class

Another accident dimension to be kept in mind in assessing the road/footpath cycling issue is that of injury severity. Table 2 presents proportions of footpath and non-footpath involved cyclist involvements by severity level for the study area.

Table 2 Severity Level Distribution (%) by Accident Type

Accident type	Severity level		
	Killed	Admitted to hospital	Required medical treatment
Footpath	-	42.8	57.2
Non-footpath	1.9	33.2	64.9

It is difficult to interpret this table without making assumptions about reporting rates within accident type. However, two points can be made;

- all cyclist fatalities involved riding on the road (rideout behaviour did not contribute to these [8] cases)
- while non-fatal accidents appear to be more severe on the footpath (i.e. hospital admission is more likely if footpath riding is involved), this could be because of some footpath related injury accidents escaping both the Police and Hospital based reporting systems. This would have the effect of increasing the proportions of the more severe injury levels. Further work is required to clarify the issue of the relative (non-fatal) injury severity of footpath and non-footpath related accidents.

Figure 14 presents risk estimates by accident type (road related or footpath related) and accident data source. It should be noted that the process for scaling up the hospital-sourced data was, by necessity, less rigorous and that, regardless of source, absolute risk estimates should be viewed with caution. The results contained in Figure 14 do indicate that, despite doubts on the absolute magnitude of risk estimates, their relative standing does provide a valid basis for decision making as both sets of results are in the ratio of around 2.5 to 1.

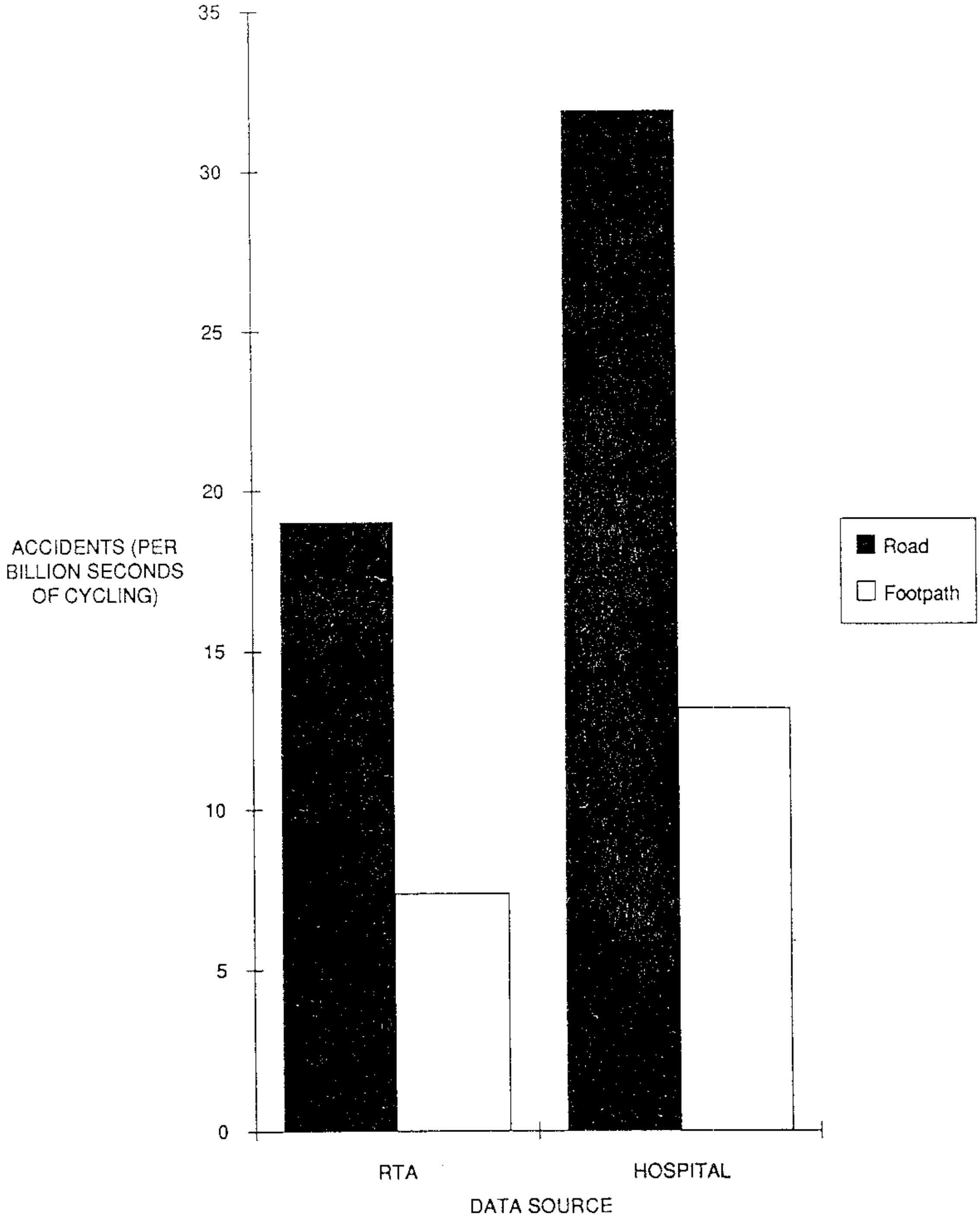

Figure 14 Risk estimates by accident type and data source

The final result at a general level looks at road and footpath accident involvement risk by weekday and weekend. Figure 15 demonstrates that the ratio of road to footpath risk is relatively stable over the two week blocks, with weekend footpath cycling being the least risky activity. Weekend cycling is safer than its weekday counterpart and, as could be expected, footpath cycling is always safer than road cycling.

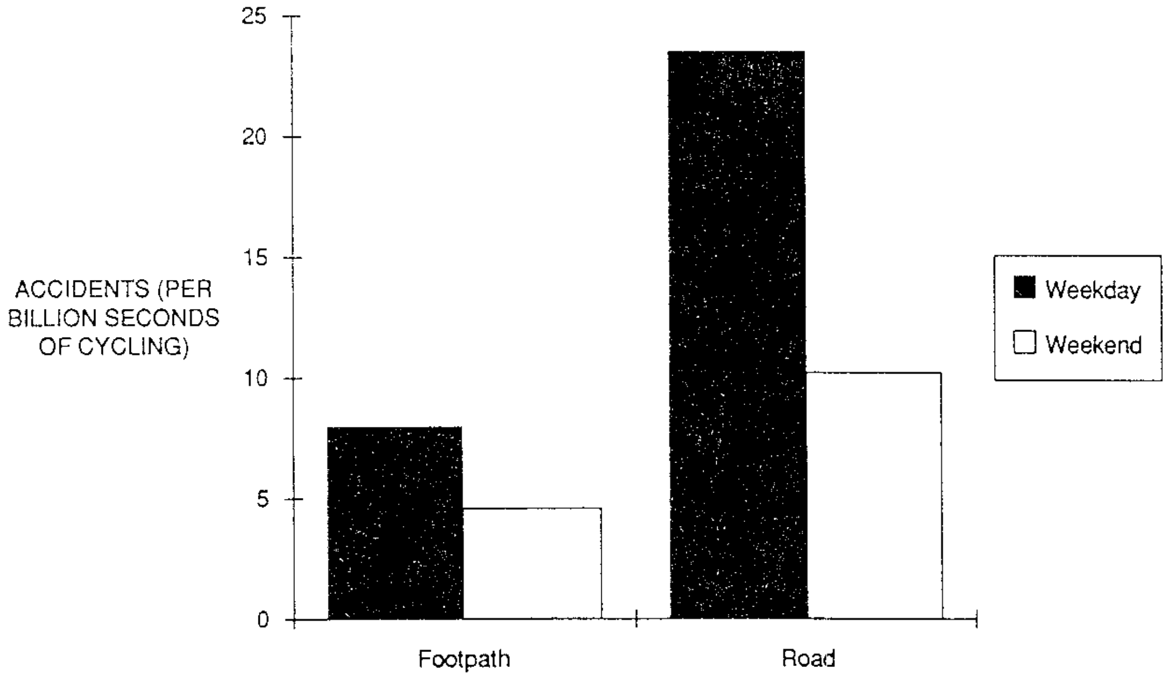

Figure 15 Footpath and road risk estimates by weekday/weekend

5.4 DETAILED ANALYSES

This section presents the more detailed analyses which are required to gain a better understanding of safe and unsafe cycling behaviour.

Figure 16 presents risk estimates by age group, road class and accident type. As mentioned previously, this disaggregation controls for the variations in exposure to risk which accompany cycling behaviour by different age groups on different types of roads. The figure shows;

- arterial roads are the most dangerous cycling location, especially for 11-17 year olds whose risk is nearly three times greater than the other two age groups.
- footpath cycling is appreciably safer, although the improvement in cycling safety is least (in both absolute and percentage terms) for the youngest group of cyclists.
- cyclists aged 18 years or more show the smallest rate of improvement when arterial to non-arterial roads are compared by age group.
- cycling on arterial footpaths is a riskier activity than cycling on non-arterial roads (because of the enormous danger of transitional cycling, as Figure 17 demonstrates).

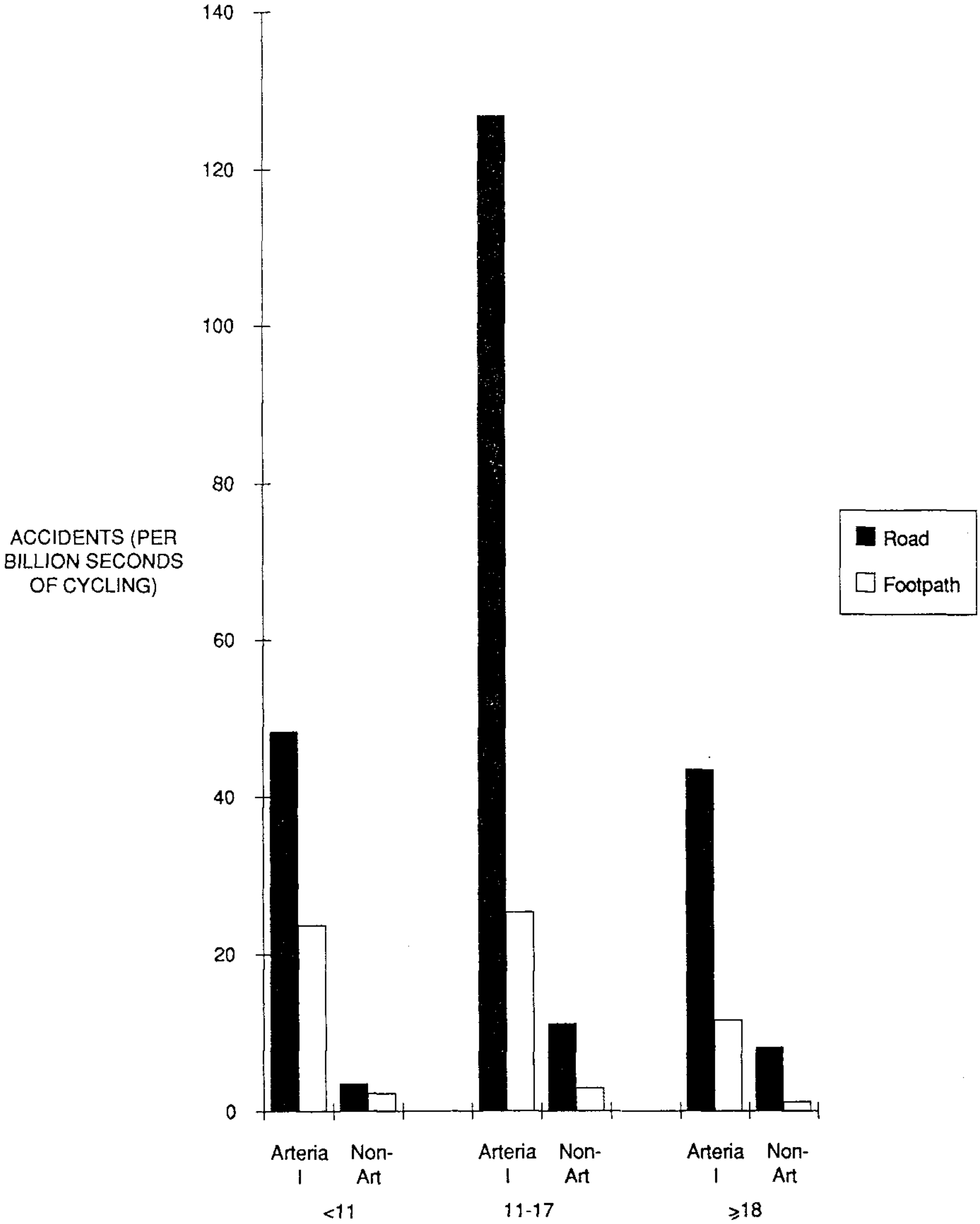

Figure 16 Risk estimates by accident type, age group and road class

To date in the presentation of results, the 'footpath' accident type has included both footpath accidents and transitional (intersection and midblock) rideout accidents, so that this accident type represents all footpath related accidents. In Figure 17, the footpath accident type is split into its two constituent elements (it should be remembered that the intersection and midblock rideout counts have been assigned a nominal two seconds each so that they can be compared with the other two time-based risk estimates).

It should also be noted that accidents where a person cycles from a property **across** the footpath and onto the road are not classified as rideout accidents in this study, but are counted as on-road accidents. This accident type represents some 5% of cyclist involvements; given the nature of the preceding behaviour, it is considered to be an issue which should be addressed in its own right.

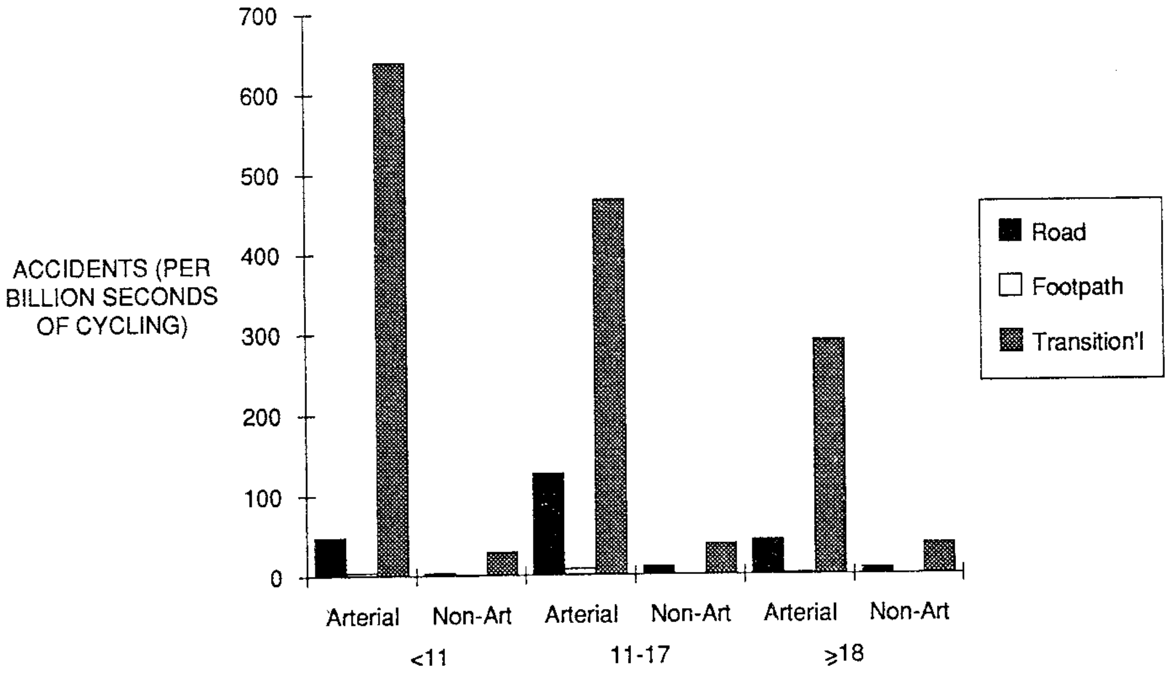

Figure 17 Risk estimates by expanded accident type, age group and road class

The chart presents the very large imbalance in risk between transitional and both road and footpath cycling. When transitional cycling is excluded from the footpath accident type, it is seen that the relative safety of footpath cycling is greatly enhanced. As indicated above, the risk of transitional cycling on arterial roads is much greater (because, presumably, the probability of a vehicle being present when a rideout is committed is that much greater).

The analysis now concentrates on the risk estimates of the various behavioural classes that were concurrently collected. It should be emphasised that the risk denominator is specific to the behaviour being analysed. Unlike the previous risk estimates where the product was always accidents per billion cycling seconds and the comparison of different risk estimates could be validly undertaken, such comparisons are restricted to within a figure for the following analyses.

Figure 18 demonstrates that the greatest risk of accident involvement following an intersection rideout is associated with 11 to 17 year old cyclists on arterial roads. The danger of this manoeuvre is concentrated on the arterial environment interestingly, the youngest cyclist age group (under 11 years) has a much lower overall risk for this behaviour (although the ratio of arterial to non-arterial is greatest for this group).

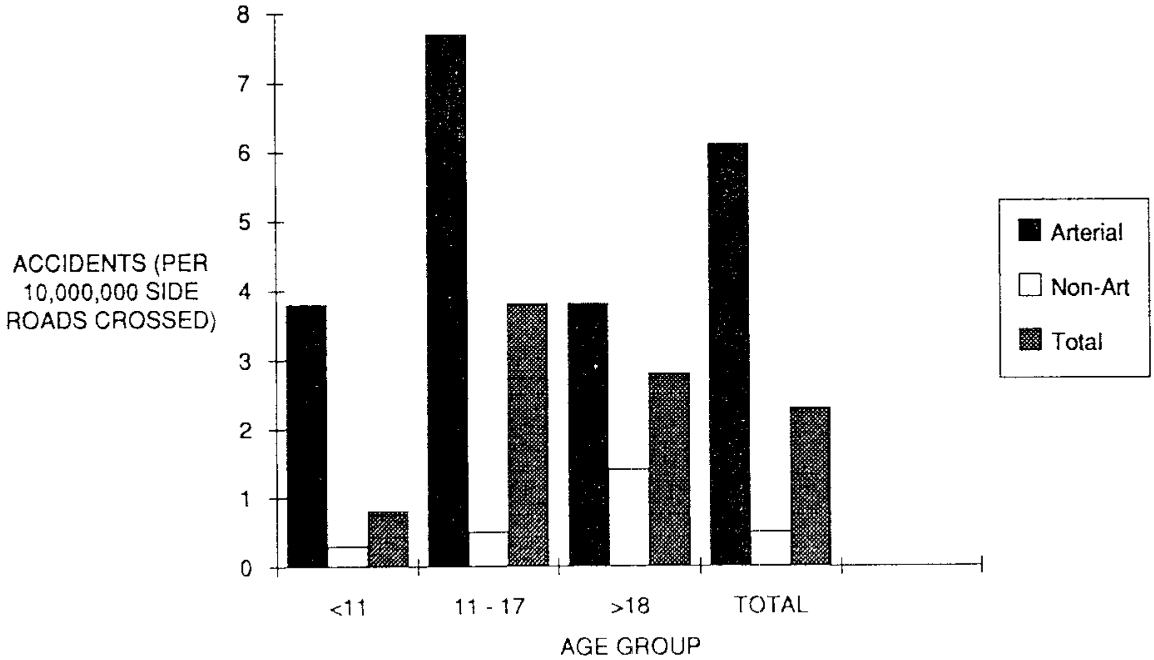

Figure 18 Intersection rideout risk (per 10,000,000 side roads crossed) by age group and road class

When the complementary behavioural class of passing side streets while cycling on the road is investigated, the results (Figure 19) show that the single greatest problem again lies with the 11 to 17 year old age group on arterial roads. While cyclists under 11 years of age contribute almost 20% of this behaviour's exposure, they represent only 1% of reported accidents. Differential reporting by age for this accident type is difficult to entertain; nevertheless, this particular result is an odd finding.

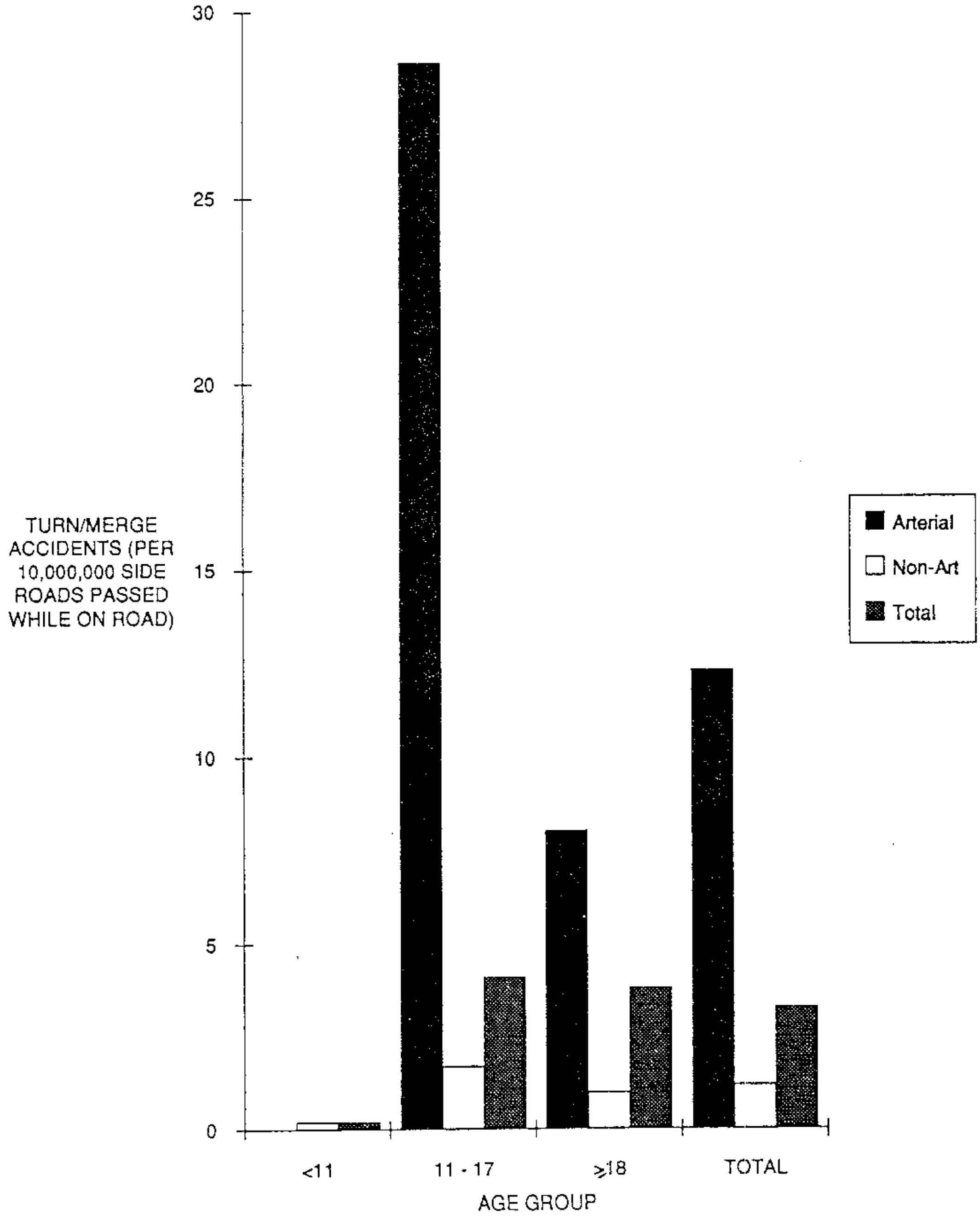

Figure 19 Risk of a motorist turn/merge accident (per 10,000,000 side roads passed while on the road) by age group and road class

Figure 20 combines the data from the previous two graphs and presents relative risk estimates for bicyclist accidents at intersections. The risk estimates are relative to the risk for all cyclists being involved in an accident at an intersection. The obvious highlight of this presentation is the 11 to 17 year old age group on arterial roads, a circumstance which is some 9.5 times more dangerous than the overall level of intersection accident risk. The results also generally show that, for both road classes, the risk of an intersection accident is higher when the cyclist is riding on the road.

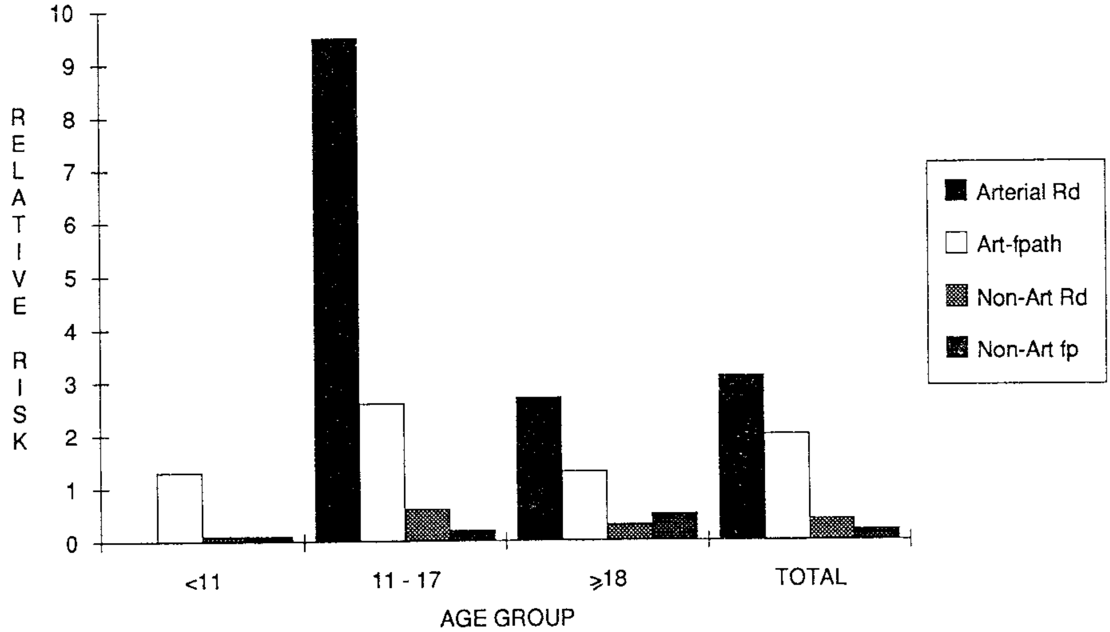

Figure 20 Relative risk * *when crossing/passing side streets by road class and age group*

Figure 21 presents the risk associated with midblock rideouts (per 10,000,000 rideouts) by age group and road class. Unlike the **pattern** for intersection rideouts, midblock rideouts pose a much greater safety problem for the youngest cyclist group. Relative to the arterial network, midblock rideouts in the non-arterial environment are associated with a much lower level of risk for all age groups.

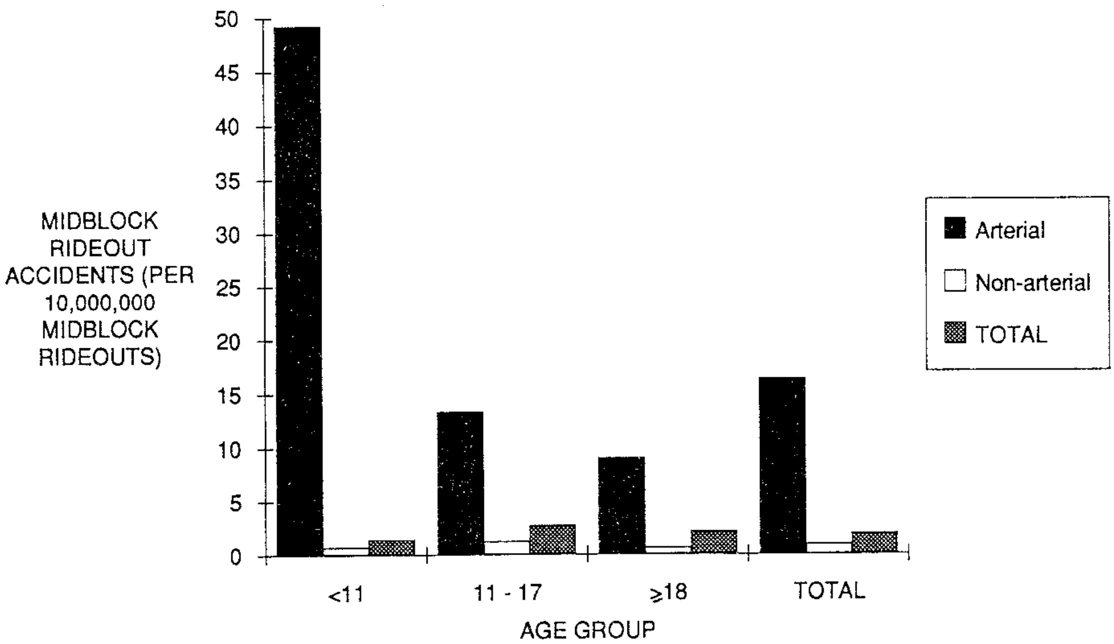

Figure 21 Risk of midblock rideout (per 10,000,000 rideouts) by age group and road class

* The risk of all cyclists being involved in either intersection rideout or motorist turn/merge (while cycling on the road) accidents (i.e. the grand total of Figures 18 & 19 combined) has been set to unity.

The results for a subset of footpath related accidents, those where a footpath cyclist collides with a vehicle emerging from a driveway, are shown in Figure 22. There were relatively few accidents associated with this manoeuvre (a yearly average of 12.5 in the study area) and consequently the inherent risk per driveway is very small as it is a frequent (unavoidable) footpath cycling behaviour. The graph presents risk estimates per 10,,000,000 driveways crossed and shows the pattern to be reasonably uniform across age groups, with a much higher relative risk associated with arterial footpaths.

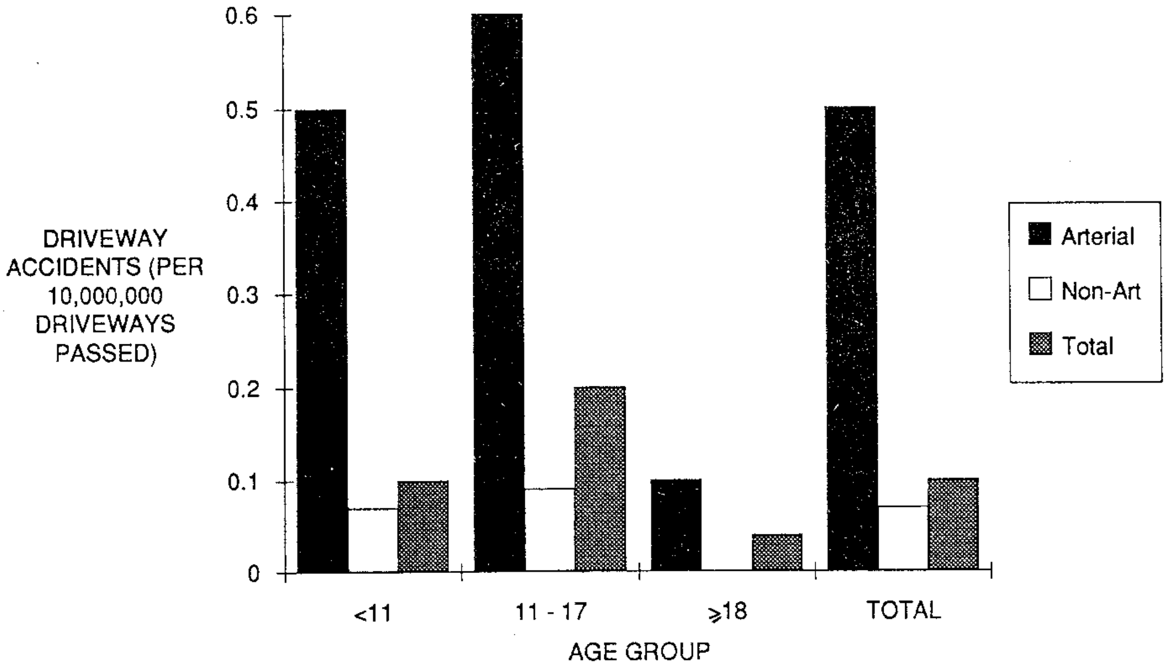

Figure 22 Risk of driveway car/footpath cyclist accident (per 10,000,000 driveways passed) by age group and road class

The pattern presented in Figure 23 is quite different to previous examples. This figure presents the risk of a motorist overtaking accident (per 10,000,000 cars passing the cyclist) and while the highest risk level is associated with 11 to 17 year old cyclists on arterial roads, it is interesting to note that, for' this age group, the risk of this accident type on non-arterial roads is almost as high.

Although, accident numbers are small (and thus the risk estimate could vary appreciably), this circumstance is more dangerous on non-arterial roads for the oldest cyclist group. Overall, this activity poses greater problems for cyclists under 18 years of age, suggesting perhaps more erratic or unpredictable cycling behaviour.

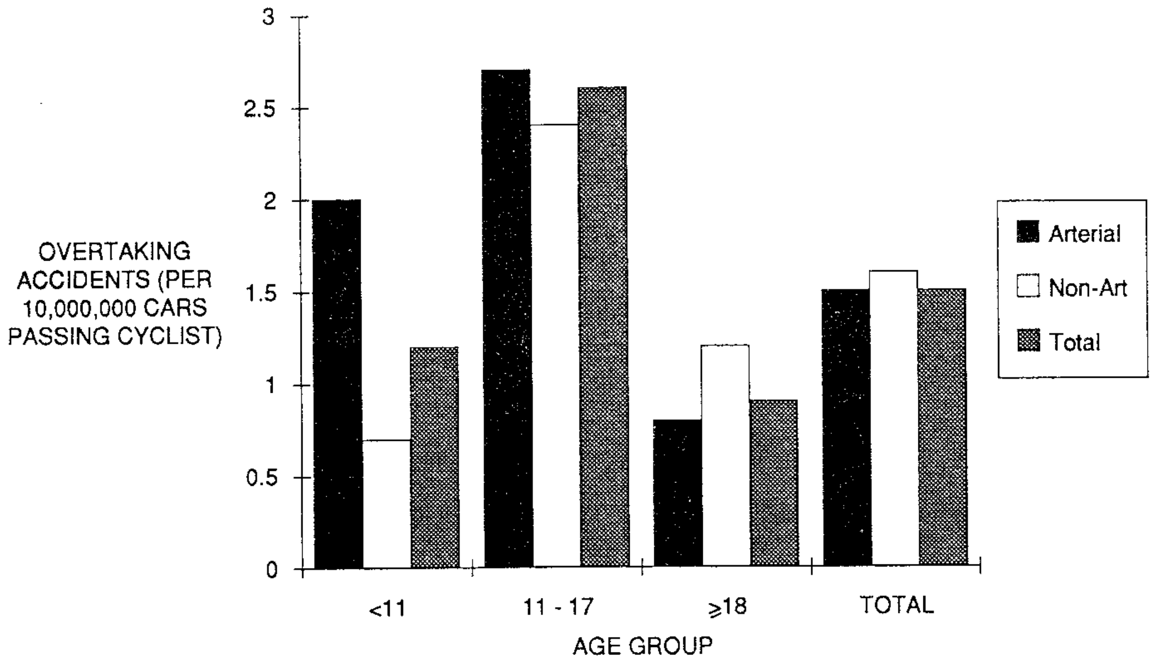

Figure 23 Risk of motorist overtaking accidents (per 10,000,000 cars passing cyclist) by age group and road class

The final figure in this section presents risk estimates for cyclist-pedestrian collision on the footpath. It should be noted that the weakest link in the accident chain is the bicyclist-pedestrian collision in which the pedestrian is injured. Such accidents were not covered by the prospective hospital study and so it is very difficult to place Figure 24 in context. It is pointed out that the risk estimates are based on only 2.5 accidents (an annual average); this does indicate that the specific underreporting problem for this accident type would need to be very substantial for it to approach the size of other, more general bicycle accident types.

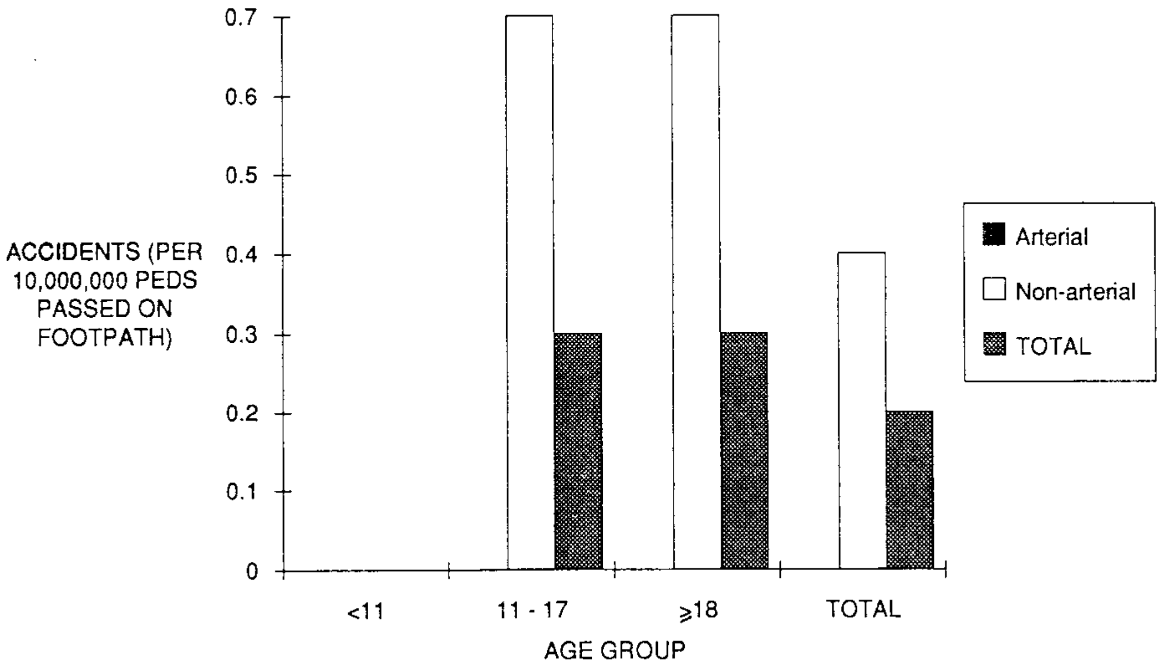

Figure 24 Risk of cyclist/pedestrian (on footpath) accidents (per 10,000,000 pedestrians passed) by age group and road class

5.5 OTHER ANALYSES

To maximise the utility of the data collection phase, information on cyclist helmet wearing was also collected. **The results presented below exclude unknown cases; both non-holiday and holiday results are reported (separately).**

The first graph (Figure 25) presents the helmet wearing by age group result using data collected during the exposure study and also data from the 1987 helmet wearing surveys conducted by the RTA. It should be noted that there are important methodological differences between the two data sources, the most important being the fact that RTA surveys of school-age cyclists are school-based.

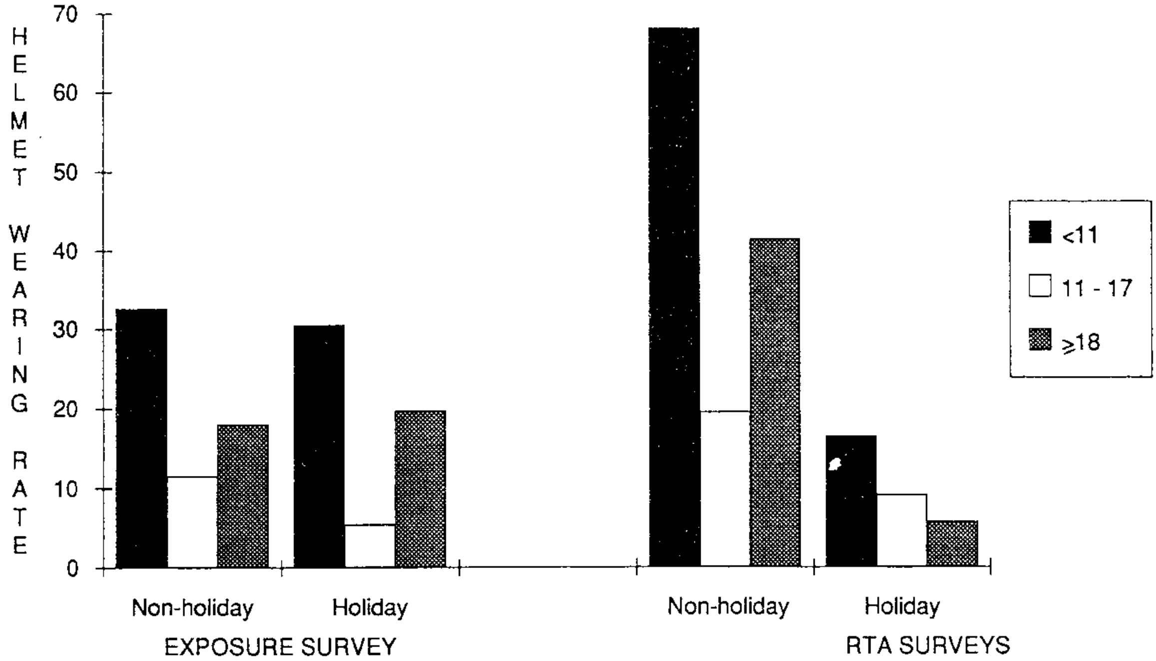

Figure 25 Helmet wearing rates by age group, period and source

* non-arterial sites only.

Figure 26 attempts to reduce the methodological differences by presenting exposure study-based results as school related or not school related. School related cycling was defined as occurring between the hours of 8am to 9am and 3pm to 4pm.

While such an approach is an approximation at best, it can be seen that the rate of helmet wearing in the defined school related cycling time is nigher than the overall average. Nevertheless, the rates for primary school aged cyclists is still much lower than the equivalent RTA estimate (the rates for secondary school aged cyclists are now comparable).

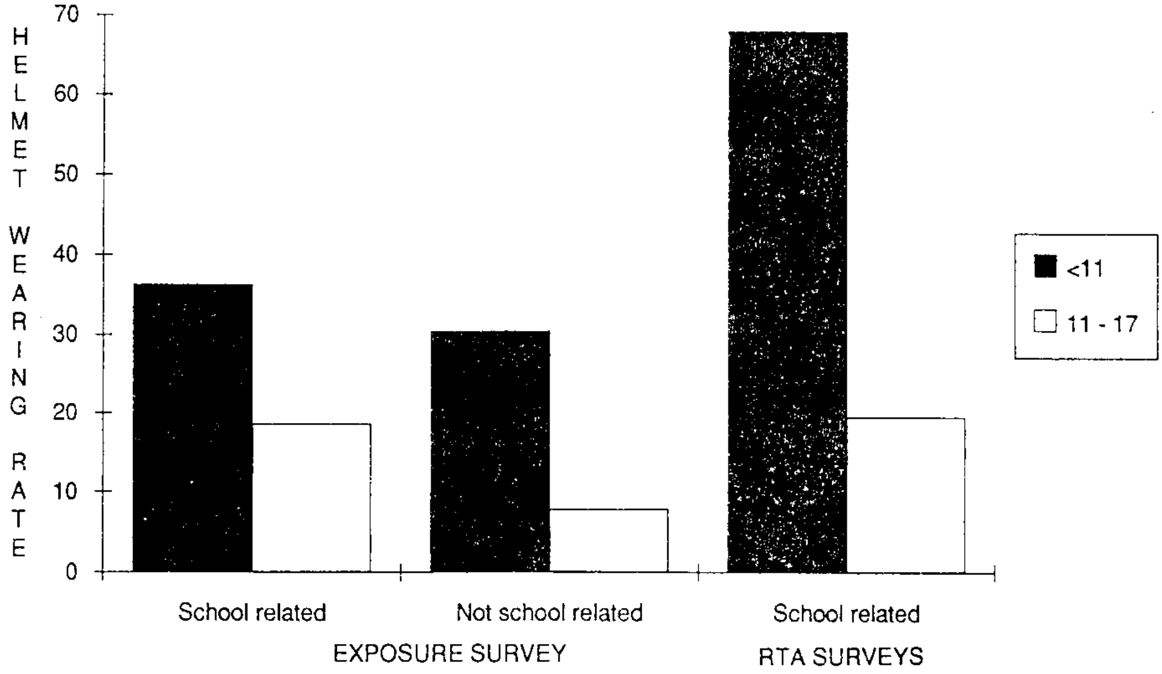

Figure 26 Helmet wearing rates by age group, type of travel and source

The final result in this section presents overall helmet wearing rates by road class and period. These data are from the exposure study only and show that wearing rates are higher on the arterial network (see Figure 27).

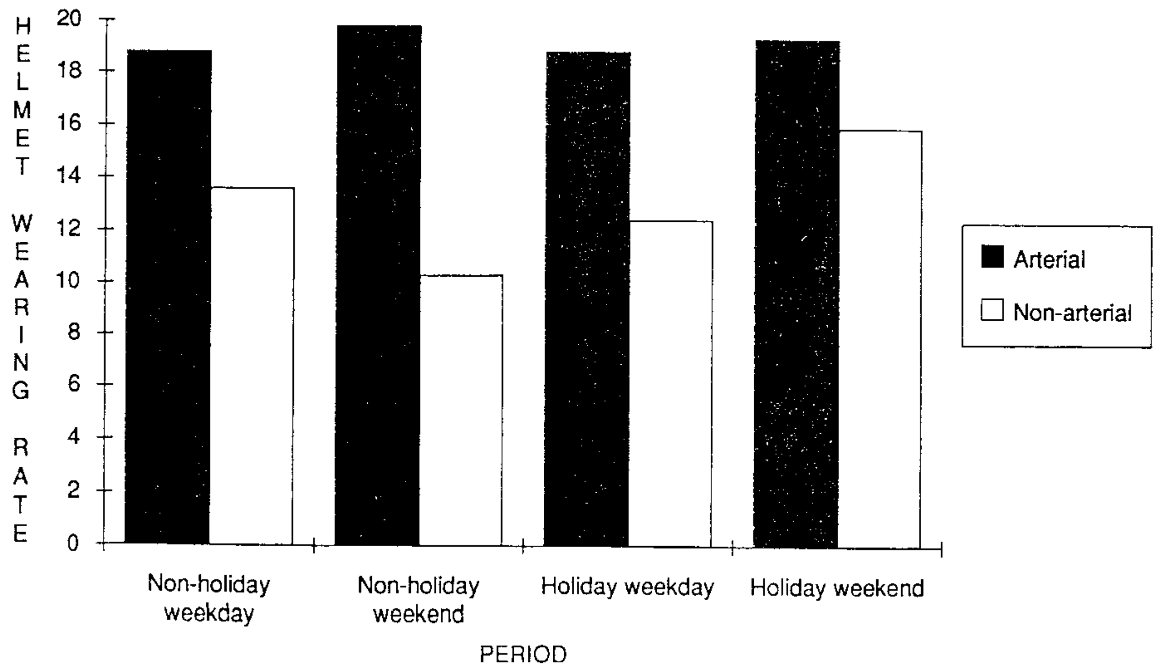

Figure 27 Helmet wearing rates by period and road class

6.0 CONCLUSION

This report has detailed the design and conduct of a bicyclist exposure study in metropolitan Melbourne and the subsequent calculation of bicyclist accident involvement risk estimates, using comparable accident data. Results were provided on exposure patterns, risk estimates of both road and footpath cycling and their interactions, risk estimates of selected behavioural components and helmet wearing.

A general interpretation of the' comprehensive set of results presented in this report indicates that the safety benefits of allowing footpath cycling along arterial roads would be much greater than in the non-arterial environment. Significant improvements in the safety of footpath cycling could be accomplished if effective strategies to reduce the incidence of transitional, rideout cycling could be implemented.

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APPENDIX 1

THE SITE SELECTION PROCESS

The site selection process was as follows;

1. For each study region, all pages (partial or complete) of the Melways which make up the region were defined. This was stored in a computer database.

2. A computer program randomly selected (with replacement) a Melways page number appropriate for the region, as well as a randomly selected grid co-ordinate. The program also generated a random sequence of the four main compass points and a random sequence of the eight main compass points. An example is given below.

Page	X-Y Co-Ord	Link Dir.	Search Direction
47	F 6	E,N,S,W	N,SE,NE,W,NW,S,E,SW

3. Before selecting the site, decide on the road classification of the site, i.e. arterial or non-arterial.

   Using the page number and X-Y co-ordinate, locate the grid. Select the intersection closest to the centre of the grid and the link closest to the first link direction specified. If the link satisfies the criterion for the road class, this site is selected.

   If the link failed on the road class criterion, the three remaining link directions were tried in turn in order to find a. suitable site. If this process was unsuccessful (or the grid contained no intersections to start with), the search was transferred three grids in the direction specified by the alternate search direction and the process repeated.

   The above steps were repeated until enough sites in both road classes had been selected.

APPENDIX 2

LISTING OF SITES

APPENDIX 2

LISTING OF SITES

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 F8	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

SITE NO.	MELWAY REF.	SAMPLED STREET	INTERSECTING STREET	DIRECTION FROM I/SECTION
Non-Arterial Sites [10]				
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 NTH RD.	CHURCHILL PARK DR.	SOUTH
41	49 D9	HEATHERDALE RD.	MAROONDAH HWY.	SOUTH
42	73 B11	KELLETS RD.	TAYLORS LA.	WEST
43	33 B4	TEMPLESTOWE RD.	THOMPSONS 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	WHALLEY 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]

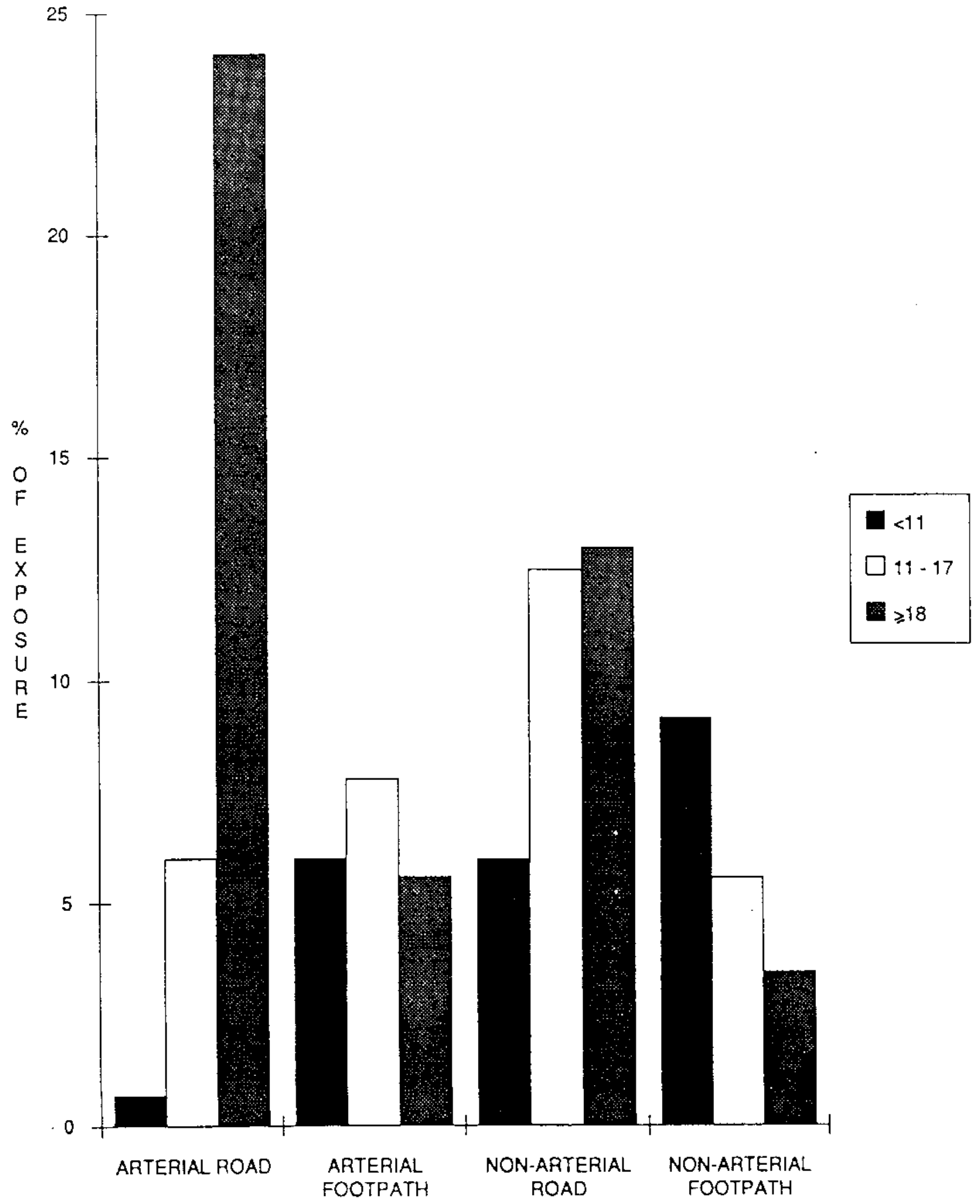
90	77 B5	ROYDON ST.	WISHART ST.	EAST
91	97 F7	DAHMEN ST.	MCLEOD RD.	NORTH
92	95 C1	HAMMOND RD.	RHUR CT.	SOUTH
93	92 F1	ALBERT ST.	PARK ST.	S/EAST
94	77 H7	GENOA ST.	BULLI ST.	EAST
95	86 D7	JOHN ST.	EDITH ST.	EAST
96	81 B6	BLAXLAND DVE.	POLICE RD.	SOUTH
97	103 D3	LUCERNE CR.	SASSAFRAS DVE.	SOUTH
98	105 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

EXPOSURE PATTERNS AND RISK ESTIMATES FOR THE HOLIDAY PERIOD

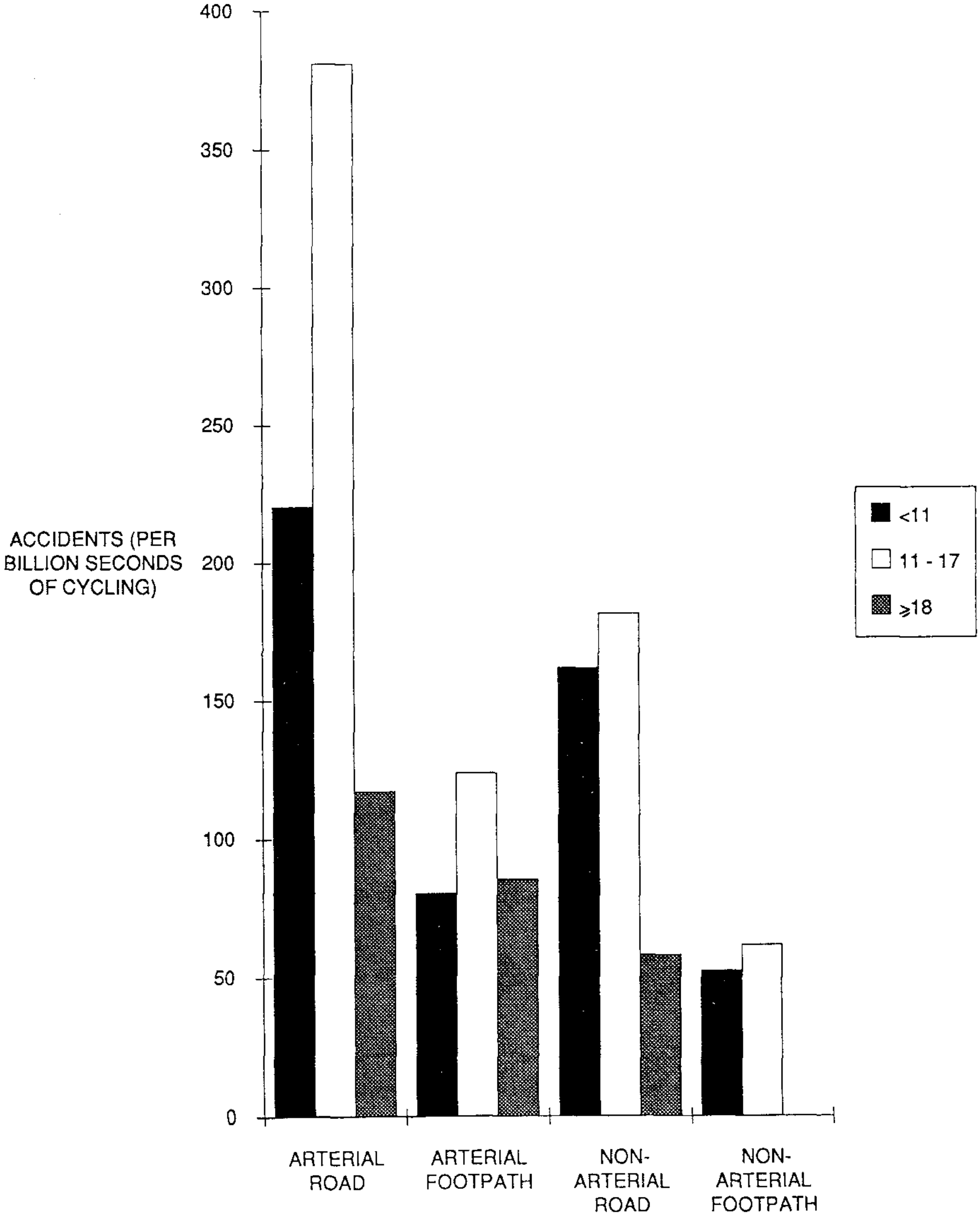
This appendix presents both exposure data and risk estimates cross-classified by age group and road class for the holiday period. As mentioned in the report, the numbers are relatively small, so the results presented below should be regarded as indicative only.

The first figure shows exposure patterns by age group and road class. Relative to Figures 4 & 5 in the main body of the . report, it demonstrates a greater usage of the arterial environment (1 : 1 c.f. 1 : 5 in non-holiday periods) . The road to footpath ratio remains roughly constant at 2 : 1.



Holiday exposure patterns by age group and road class

The second figure shows accident involvement risk estimates by accident type, age group and road class. On these results, it appears that cycling in holiday periods is riskier than non-holiday periods (refer to Figure 14) . The elevation in risk is most notable for the youngest group of cyclists (the relative safety of footpath cycling is greatly enhanced in this period).



Risk estimates by accident type, age group and road class

APPENDIX 4

CYCLING SURVEY FORM

APPENDIX 4

CYCLING SURVEY FORM

SITE NO: ____________ DATE: / / ROAD CLASS: ARTERIAL 1 LOCAL 2 END OF ZONE: ....
(Name of street)

DAY OF WEEK: MON 1 TUE 2 WED 3 THUR 4 FRI 5 SAT 6 SUN 7 TIME OF DAY: MORNING 1 AFTERNOON 2

PERIOD : NON-HOLIDAY 1 HOLIDAY 2 LAND USE : RESIDENTIAL 1 SHOPS 2 INDUSTRIAL 3 PARKS/SCHOOLS 4 OTHER 5

BEHAVIOURS

HOUR/ WEATHER (fine=F) (rain=R) VEHICLE COUNT	AGE	SEX (M=1) (F=2) (?=3)	HELMET (Y=1) (N=2)	TIME (secs) ROAD	TIME (secs) FOOTPATH	PED & CYCST PASSED (when on foot-path) PED	PED & CYCST PASSED (when on foot-path) CYCST	SIDE ROADS CROSSED (when on foot-path)	MIDBLOCK RIDE-OUT (from foot-path to road	DRIVEWAYS PASSED (when on foot-path)	CARS PASSING (when on road)	SIDE STREETS PASSED (when on road

I certify that I have undertaken the above observations in accordance to the instruction. Signed ....

CYCLING SURVEY FORM

SITE NO: ______________ DATE: / / TIME OF DAY: MORNING 1 AFTERNOON 2

HOUR/ WEATHER (fine=F) (rain=R) VEHICLE COUNT	AGE	SEX (M=1) (F=2) (?=3)	HELMET (Y=1) (N=2)	TIME (secs)		PED & CYCST PASSED (when on foot-path)		SIDE ROADS CROSSED (when on foot-path)	MIDBLOCK RIDE-OUT (from foot-path to road	DRIVEWAYS PASSED (when on foot-path)	CARS PASSING (when on road)	SIDE STREETS PASSED (when on road
				ROAD	FOOTPATH	PED	CYCST					

I certify that I have undertaken the above observations in accordance to the instruction. Signed ....

APPENDIX 5

DATABASE FORMAT

DATABASE FORMAT

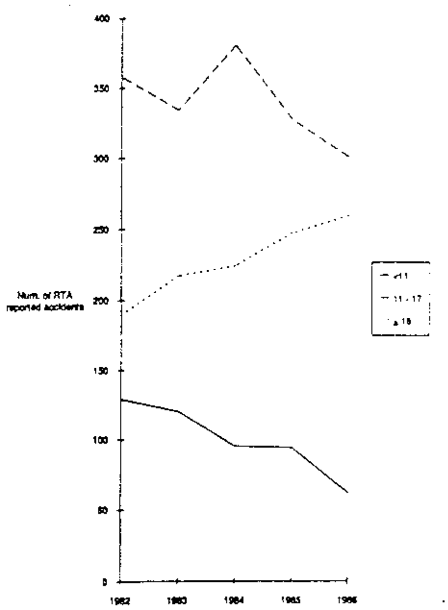
COLUMNS	DESCRIPTION	CODES
1-5	SITE NUMBER	
6-10	SESSION NUMBER	
11-15	LINK LENGTH	
16-19	DAY	
20-23	MONTH	
24-27	YEAR	
28-30	DAY OF WEEK	MONDAY=1 TO SUNDAY=7
31-33	TIME OF DAY	AM=1, PM=2
34-36	PERIOD	NON-HOLIDAY=1, HOLIDAY=2
37-39	LAND USE	RESIDENTIAL=1, SHOPS=2, INDUSTRIAL=3, PARKS/SCHOOLS=4, OTHER=5
40-42	ROAD CLASS	ARTERIAL=1, NON-ARTERIAL=2
43-45	FOOTPATH?	ONE SIDE=1, BOTH SIDES=2, NO FOOTPATH=3
46-51	HOUR OF DAY	800=8AM TO 9AM, 1500=3PM TO 4PM, ETC
52-54	WEATHER	FINE=1, RAINING=2
55-58	VEH COUNT - IN	
59-62	VEH COUNT - OUT	
63-66	AGE	
67-69	SEX	MALE=1, FEMALE=2, UNSURE=3
70-72	HELMET WEARING	YES=1, NO=2, N/A=3
73-76	TIME ON ROAD	

77-80	TIME ON FOOTPATH
81-83	PEDESTRIANS PASSED
84-86	CYCLISTS PASSED
87-89	SIDE ROADS CROSSED
90-92	MIDBLOCK RIDEOUTS
93-96	DRIVEWAYS PASSED
97-100	CARS PASSING
101-103	SIDE STREETS PASSED

APPENDIX 6

BICYCLE ACCIDENT DATA TRENDS

As noted in the text, bicycle accident data trends for the study area and period were checked to determine the validity of combining 1984 and 1985 accident data with exposure data which were collected in 1987 (the two components of the risk ratio should ideally be contemporaneous). The graph below shows the pattern of reported bicyclist involvements by year and age group in the study area.



Graph 1 Bicyclist involvements in the study area by year and age group

The data do show a decreasing series for the youngest age group, a reasonably stable pattern for the 11 to 17 years old age group and a consistently increasing series for the oldest age group. It could be speculated that the accident pattern for the youngest age group is reflecting the benefits of increased helmet wearing (with exposure patterns remaining constant) while increased bicycle usage may explain the trend for adult cyclists (in which case the reported risk estimates would be underestimated).

The 1984 to 1986 accident ratios for the three age groups is 1 : 4.0 : 2.9. The same ratio for the 1984/85 period is 1 : 3.7 : 2.5. These departures are not considered sufficiently large to invalidate the approach adopted. While it is recommended that further processing of more recent (1987) accident data be undertaken with a view to refining the risk estimates, the effect of such work on the interpretation of the general findings of this report is likely to be minimal.

APPENDIX 7

CLASSIFICATION OF ACCIDENT TYPES INTO BEHAVIOURAL COMPONENTS

ACCIDENT TYPE	BEHAVIOURAL COMPONENT	COMMENTS
A03	2	ONLY WHEN PRE-CRASH PATH IS PARALLEL; NOT AT INTERSECTION
A04	2	IF FOOTPATH ENDORSED
B05	1	IF FOOTPATH ENDORSED
B06	1	IF FOOTPATH ENDORSED
B07	1	IF FOOTPATH ENDORSED
#49	1	IF FOOTPATH ENDORSED
C08	3	IF FOOTPATH ENDORSED
C09	5 1	IF **NOT** FOOTPATH ENDORSED IF FOOTPATH ENDORSED
C10	5 1	IF **NOT** FOOTPATH ENDORSED IF FOOTPATH ENDORSED
C11	3	IF FOOTPATH ENDORSED
C12	5 1	IF **NOT** FOOTPATH ENDORSED IF FOOTPATH ENDORSED
#48	5 1	IF **NOT** FOOTPATH ENDORSED IF FOOTPATH ENDORSED
D13	4	
D14	4	IF MOTORIST IN SAME DIRECTION AS CYCLIST
D15	4	
D16	4	
D17	4	
E18	4	
E20	4	IF MOTORIST IN SAME DIRECTION AS CYCLIST

E21	4	
F22	5	IF POSITION CODE=1 AND **NOT** FOOTPATH ENDORSED
	1	IF POSITION CODE=1 AND FOOTPATH ENDORSED
F23	5	IF POSITION CODE=1
	1	IF POSITION CODE=2
F24	5	IF **NOT** FOOTPATH ENDORSED
	1	IF FOOTPATH ENDORSED
G25	5	IF **NOT** FOOTPATH ENDORSED
	1	IF FOOTPATH ENDORSED
#55	5	IF **NOT** FOOTPATH ENDORSED
	1	IF FOOTPATH ENDORSED
G26	4	
G28	4	
G30	4	
SUBSIDIARY CODES		
37	3	IF FOOTPATH ENDORSED
44	6	IF FOOTPATH ENDORSED
45	6	IF FOOTPATH ENDORSED
47	1	IF FOOTPATH ENDORSED

APPENDIX 8

EXPOSURE PATTERNS

NOTE: ***Time-based exposure data in the following tables are reported in units of 1,000 seconds for ease of presentation. Thus, cyclist exposure on arterial roads (Figure 4), given in the table as 2,850,948, equates to an exposure figure of 2,850,948,000 seconds.***

EXPOSURE PATTERNS

FIGURE 4 Rd/Fpath Exposure x Road Class (%)

	Rd	F/path	Total
Arterial	2,850,948 (9.8)	1,940,044 (6.7)	4,790,992 (16.5)
Non-arterial	16,027,221 (55.4)	8,137,474 (28.1)	24,164,695 (83.5)
Overall	18,878,169 (65.2)	10,077,518 (34.8)	28,955,687 (100.0)

FIGURE 5 Arterial Exposure x Rd/Fpath x Agegroup

	<11	11-17	≥18	TOTAL
Road	217,288 (4.5)	765,015 (16.0)	1,868,645 (39.0)	2,850,948 (59.5)
F/path	442,234 (9.2)	1,023,990 (21.4)	473,820 (9.9)	1,940,044 (40.5)
TOTAL	659,522 (13.8)	1,789,005 (37.3)	2,342,465 (48.9)	4,790,992 (100)

FIGURE 5 Non-Arterial Exposure x Rd/Fpath x Agegroup

	<11	11 - 17	≥18	TOTAL
Rd	5,925,570 (24.5)	7,029,193 (29.1)	3,072,458 (12.7)	16,027,221 (66.3)
F/Path	4,201,112 (17.4)	2,655,783 (11.0)	1,280,579 (5.3)	8,137,474 (33.7)
TOTAL	10,126,682 (41.9)	9,684,976 (40.1)	4,353,037 (18.0)	24,164,695 (100)

FIGURE 6 All Roads x Rd/Fpath x Agegroup

	<11	11 - 17	⩾ 18	TOTAL
Rd	6,142,858 (21.2)	7,794,208 (26.9)	4,941,103 (17.1)	18,878,169 (65.2)
F/Path	4,643,346 (16.0)	3,679,773 (12.7)	1,754,399 (6.1)	10,077,518 (34.8)
TOTAL	10,786,204 (37.3)	11,473,981 (39.6)	6,695,502 (23.1)	28,955,687 (100)

FIGURE 7 Arterial Exposure x Weekday/Weekend x Agegroup and Road/Footpath

	<11	11 - 17	⩾18	TOTAL
W/DAY (rd)	181,224 (3.8)	546,342 (11.4)	1,179,657 (24.6)	1,907,223 (39.8)
W/DAY (f/path)	265,794 (5.5)	700,949 (14.6)	266,564 (5.6)	1,233,307 (25.7)
W/END (rd)	36,064 (0.8)	218,673 (4.6)	688,988 (14.4)	943,725 (19.7)
W/END (f/path)	176,440 (3.7)	323,041 (6.7)	207,256 (4.3)	706,737 (14.8)

FIGURE 8 Non-arterial Exposure x Weekday/Weekend x Agegroup and Road/Footpath

	<11	11 - 17	⩾18	TOTAL
W/DAY (rd)	3,925,308 (16.2)	4,728,621 (19.6)	1,938,818 (8.0)	10,592,747 (43.8)
W/DAY (f/path)	2,332,977 (9.7)	1,776,230 (7.4)	1,006,858 (4.2)	5,116,065 (21.2)
W/END (rd)	2,000,262 (8.3)	2,300,572 (9.5)	1,133,640 (4.7)	5,434,474 (22.5)
W/END (f/path)	1,868,135 (7.7)	879,553 (3.6)	273,721 (1.1)	3,021,409 (12.5)

FIGURE 9 Exposure x Agegroup x Sex x Road Class

	<11	11 - 17	≥18	TOTAL
MALE (art)	304,041 (1.3)	1,487,947 (6.3)	1,975,858 (8.3)	3,767,848 (15.9)
MALE (non-art)	4,163,296 (17.5)	8,440,560 (35.6)	3,437,229 (14.5)	16,041,085 (67.6)
FEMALE (art)	83,321 (0.4)	293,412 (1.2)	355,416 (1.5)	732,419 (3.1)
FEMALE (non-art)	1,102,621 (4.6)	1,179,004 (5.0)	905,868 (3.8)	3,187,493 (13.4)

FIGURE 10 Exposure x Agegroup and Landuse

	<11	11 - 17	≥ 18	TOTAL
Residential	9,096,047 (31.4)	8,924,305 (30.8)	4,252,459 (14.7)	22,272,811 (76.9)
Shops	85,829 (0.3)	277,741 (1.0)	372,167 (1.3)	735,737 (2.5)
Industrial	94,256 (0.3)	93,666 (0.3)	358,855 (1.2)	546,777 (1.9)
Parks/Schools	119,817 (0.4)	796,683 (2.8)	541,076 (1.9)	1,457,576 (5.0)
Other	1,390,255 (4.8)	1,381,406 (4.8)	1,170,945 (4.0)	3,942,606 (13.6)

FIGURE 11 Pedestrian Passing Rates Each Day (on footpath) x Agegroup and Road Class (days = 282.8)

	Agegroup	Pedpass	Road length	Rate (per km)
ARTERIAL	<11	18,021,000	1,794	35.5
	11 - 17	42,533,000	1,794	83.8
	>18	9,214,000	1,794	18.2
NON-ARTERIAL	<11	39,031,000	10,703	12.9
	11 - 17	27,079,000	10,703	8.9
	>18	6,752,000	10,703	2.2

FIGURE 12 Pedestrian Passing Rates Each Day (on footpath) x Agegroup and Landuse

	Agegroup	Pedpass	Road Length	Rate(per km)
Residential	<11	22,412,000	7,223	11.0
	11 -17	27,275,000	7,223	13.4
	≥18	7,238,000	7,223	3.5
Shops	<11	8,227,000	475	61.2
	11 - 17	15,416,000	475	114.8
	≥18	6,100,000	475	45.4
Industrial	<11	458,000	1,300	1.2
	11 - 17	139,000	1,300	0.4
	≥18	50,000	1,300	0.1
Parks/Schools	<11	1,555,000	437	12.6
	11 - 17	2,805,000	437	22.7
	≥18	120,000	437	1.0
Other	<11	15,236,000	3,062	17.6
	11 - 17	23,977,000	3,062	27.7
	≥18	2,458,000	3,062	2.8

FIGURE 13 Risk Estimates x Rd/Fpath x Road Class (A = accidents, E = exposure, R = risk)

	Arterial	Non-Arterial	TOTAL
RD	A 217	A 135	A 359
	E 2,850,948	E 16,027,221	E 18,878,169
	R 76.1	R 8.4	R 19.0
F/PATH	A 49	A 23	A 76.5
	E 1,962,178	E 8,430,292	E 10,392,470
	R. 25.0	R 2.7	R 7.4

FIGURE 14 Risk Estimates x Accident Type x Source

	RTA	HOSP.
RD	A 359	A 603
	E 18,878,169	E 18,878,169
	R 19.0	R 31.9
F/PATH	A 76.5	A 139
	E 10,551,620	E 10,551,620
	R 7.4	R 13.2

FIGURE 15 Risk Estimates x Weekday/Weekend

	A	E	R
W/DAY (rd)	294	12,499,970	23.5
W/DAY (fp)	59	6,570,778	8.0
W/END (rd)	65	6,378,199	10.2
W/END (fp)	17.5	3,821,692	4.6

FIGURE 16 Risk Estimates x Accident Type x Agegroup x Rd Class

	<11	11 - 17	≥18
Arterial Rd	A 10.5 E 217,288 R 48.3	A 97 E 765,015 R 126.8	A 81.5 E 1,868,645 R 43.6
Non-Art Rd	A 21 E 5,925,570 R 3.5	A 78 E 7,029,193 R 11.1	A 25 E 3,072,458 R 8.1
Arterial F/p	A 10.5 E 442,234 R 23.7	A 26 E 1,023,990 R 25.4	A 5.5 E 473,820 R 11.6
Non-Art F/p	A 9.5 E 4,201,112 R 2.3	A 8 E 2,655,783 R 3.0	A 1.5 E 1,280,579 R 1.2

FIGURE 17 Expanded Accident Type x Agegroup x Road Class

	<11		11 - 17		≥18	
	Art	N-Art	Art	N-Art	Art	N-Art
RD	R 48.3	R 3.5	R 126.8	R 11.1	R 43.6	R 8.1
F/p	A 2 E 428936 R 4.7	A 2.5 E 3968022 R 0.6	A 8 E 980110 R 8.2	A 3 E 2527459 R 1.2	A 1 E 456564 R 2.2	A 0 E 1242325 R -
Transitional	A 8.5 E 13298 R 639.2	A 7 E 233090 R 30.0	A 20.5 E 43880 R 467.2	A 5 E 128324 R 39.0	A 5 E 17256 R 289.8	A 1.5 E 38254 R 39.2

FIGURE 18 Risk Estimates (per 10 million side roads crossed) x Agegroup and Road Class

	<11	11-17	≥18	Total
Arterial	A 2 E 5329000 R 3.8	A 12 E 15543000 R 7.7	A 2 E 5278000 R 3.8	A 16 E 26150000 R 6.1
Non Arterial	A 1 E 30987000 R 0.3	A 1 E 18935000 R 0.5	A 0.5 E 3503000 R 1.4	A 2.5 E 53425000 R 0.5

FIGURE 19 Risk Estimates (per 10 million side roads passed while on road) x Agegroup and Road Class

	<11	11-17	≥18	Total
Art	A - E 1213000 R 0	A 31.5 E 11006000 R 28.6	A 30.5 E 38195000 R 8.0	A 62 E 50414000 R 12.3
Non Art	A 1 E 49480000 R 0.2	A 18.5 E 110468000 R 1.7	A 6 E 58085000 R 1.0	A 25.5 E 218033000 R 1.2

FIGURE 20 Relative Risk of Crossing/Passing Side Streets x Road Class and Agegroup

Art - Rd	0	9.5	2.7	3.1
Art f/path	1.3	2.6	1.3	2.0
Non-art rd	0.1	0.6	0.3	0.4
Non-art f/path	0.1	0.2	0.5	0.2

FIGURE 21 Risk of Midblock Rideout (per 10 million Rideouts) by Agegroup and Road Class

	<11	11-17	≥18	Total
Art	A 6.5 E 1320000 R 49.2	A 8.5 E 6397000 R 13.3	A 3 E 3350000 R 9.0	A 18 E 11067000 R 16.3
Non-art	A 6 E 85558000 R 0.7	A 5.5 E 45227000 R 1.2	A 1 E 15624000 R 0.6	A 12.5 E 146409000 R 0.9
TOTAL	A 12.5 E 86878000 R 1.4	A 14 E 51624000 R 2.7	A 4 E 18974000 R 2.1	A 30.5 E 157476000 R 1.9

FIGURE 22 Risk of Driveway Car/Footpath Cyclist Accident (per 10 million Driveways Passed) x Agegroup and Road Class

		<11	11-17	⩾18	Total
Art	A	1.5	5.5	0.5	7.5
	E	29785000	88422000	33971000	152178000
	R	0.5	0.6	0.1	0.5
Non-Art	A	2.5	2.5	-	5
	E	372873000	265672000	87708000	726253000
	R	0.07	0.09	-	0.07
Total	A	4	8	0.5	12.5
	E	402658000	354094000	121679000	878431000
	R	0.1	0.2	0.04	0.1

FIGURE 23 Risk of Motorist Overtaking Accident (per 10 million Cars Passing Cyclists) x Agegroup and Road Class

		<11	11-17	⩾18	Total
Art	A	4	21	14	39
	E	19988000	77557000	170141000	266686000
	R	2.0	2.7	0.8	1.5
Non Art	A	2	14.5	3.5	20
	E	30113000	61567000	30372000	122052000
	R	0.7	2.4	1.2	1.6
Total	A	6	35.5	17.5	59
	E	50101000	138124000	200513000	388738000
	R	1.2	2.6	0.9	1.5

FIGURE 24 Risk of Pedestrian-Cyclist (on Footpath) Accident (per 10 million Pedestrians Passed) x Agegroup and Road Class

		<11	11-17	⩾18	Total
Art	A	-	-	-	-
	E	18021000	42533000	9214000	69768000
	R	-	-	-	-
Non-Art	A	-	2	0.5	2.5
	E	29817000	27079000	6752000	63648000
	R	-	0.7	0.7	0.4
Total	A	-	2	0.5	2.5
	E	47838000	69612000	15966000	133416000
	R	-	0.3	0.3	0.2

FIGURE 25 Helmet Wearing Rates x Source x Period of Year x Agegroup

	EXPOSURE SURVEY		RTA	
Age	Non Holiday	Holiday	Non Holiday	Holiday*
<11	32.6	30.5	67.9	16.5
11-17	11.6	5.5	19.5	9.1
≥18	18.0	19.7	41.4	5.8

* Non-arterial sites only

FIGURE 26 Helmet Wearing Rates x Source x Derived Trip Purpose x Agegroup

	EXPOSURE SURVEY		RTA
Age Group	School related	Not school related	School related
<11	36.3	30.4	67.9
11-17	18.6	7.8	19.5

FIGURE 27 Helmet Wearing Rates x Road Class x Period

	Non-hol. week	Non-hol weekend	Holiday week	Holiday weekend
Art	18.8	19.8	18.8	19.3
Non-art	13.6	10.3	12.4	15.9

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