DATA REQUIREMENTS FOR TRAFFIC SAFETY RESEARCH AND POLICY

Report presented to the 1979 Road Research Symposium on Safety of Pedestrians and Cyclists, OECD Headquarters, Paris, 14-16 May 1979
Session IV: Data requirements and evaluation procedures

R-79-8
P.C. Noordzij
Voorburg, March 1979
Institute for Road Safety Research SWOV, The Netherlands

TABLE OF CONTENTS

1. INTRODUCTION

Data requirements differ depending on the stage of the process of planning, implementation and evaluation of countermeasures. The stages referred to in this paper are presented below:

1. Selection of priority problem areas
2. Description and analysis of problems
3. Research on accident causation
4. Development and selection of countermeasures
5. Implementation and evaluation of countermeasures.

With traffic safety as the objective of all these activities there is a need for data on traffic safety at all these stages. Traffic safety is measured in terms of accidents or damage resulting from these. For different reasons there is a continuous search for substitute measures like conflict observations, feelings of safety and behaviour observations.

Accident figures are very often related to a measure of exposure. There is reasonable agreement on the definition of exposure: frequency of traffic events which create a risk of accidents (Carroll, 1973). However, there is a diversity of measures as actually applied. The reasons for this may either be of a practical nature or depend on the objective under consideration (: research or policy making). These practical or theoretical considerations require special attention when studying the safety of pedestrians and cyclists.

Other data is needed at the stages of research on accident causation as well as the development of countermeasures. Mention may be made of a.o. frequency of certain conditions, actual road user behaviour and factors determining this behaviour.

Most of the discussion on data requirements at the stage of research on accident causation is equally valid at the stage of evaluation of countermeasures.

There are all sorts of countermeasure evaluation. A distiction can be made between evaluation on an experimental base or on a large scale and as far as the last is concerned between short and long term evaluation.

The feasibility of measuring safety is closely connected with the type of evaluation as well as with the nature of the countermeasure. Exactly what data is needed depends on how the countermeasure is supposed to be effective and the wish to obtain insight into the actual effects. Up to now the effect of countermeasures has been understood as referring to traffic safety. This may already be taken in a narrow or broad sense depending on the need to know the effects on other traffic modes or other areas than the ones the countermeasure is directed at. Traffic safety measures may have other effects as well. In any case, the implementation of any measure will require a certain effort of the government, traffic safety organisations and/or road users. All of these effects will have to be considered in the selection of countermeasures. As a consequence data on all these effects is needed at the stages of selection and evaluation of countermeasures.

This paper will be restricted to the subjects of measuring safety and measuring exposure.

2. MEASURING SAFETY

2.1. Introduction

Traffic safety is measured in terms of accidents or injury and/or material damage resulting from these. However, very often the relevant accident data is not available in sufficient quality or quantity. At the stages of research on accident causation and the development and evaluation of countermeasures there is a continuous search for measures which allow interpretation in terms of traffic safety in the absence of accident data. Measures that have been considered as such substitutes are: conflict observations, feelings of safety and behaviour observations.

Apart from these applications these measures may be used otherwise. Firstly, conflicts and feelings of safety may be seen as phenomena which are undesirable in their own right. Only with a very broad definition of traffic safety will these phenomena fall under this definition, in which case they must be given a much lower rate than accidents.

Secondly, these measures may provide information which is useful to explain the causation of accidents or the effect of countermeasures. However, this is the subject of later chapters. It would be very confusing to mix the different applications in the discussion.

2.2. Accidents

A number of problems in the field of accident recording are well known such as completeness of records, classification according to seriousness and the characteristics to be recorded per accident. Most of the reports on accident research conclude with recommendations to improve accident recording (e.g. OECD, 1978). Some general remarks will be made here.

The number of light accidents is much larger in comparison to the number of serious ones. It is therefore easier to describe, analyse and interpret light accidents (plus serious ones). Mostly, however, the recording of these light accidents will be incomplete. A second problem concerns the ratio between number of serious and light accidents which may vary together with certain characteristics of the accidents. Age of road users is one of these characteristics. On the average injuries of older people are more serious than those of young ones. Such differences have been found for inside vs. outside built-up area, day- vs. nighttime, traffic mode and size of municipal population. It would be desirable to know this ratio for all classes of accidents of interest and to give a weight to the different classes of seriousness.

The characteristics to be recorded for each accident are dependent on the objective and thus the afore-mentioned stages. The selection of priority problem areas requires completeness and continuity of registration and a few global characteristics (seriousness, traffic modes of parties involved, casualties according to traffic mode, age and sex of pedestrians/drivers, same for casualties, road and traffic conditions). More characteristics are needed for the description and analysis of problems. It would be preferable if these activities could be performed on the basis of existing data.
In general much more characteristics are required at the stages of research on accident causation and countermeasure evaluation. The interest is in characteristics of the traffic situation at the time of the accident, characteristics of the pedestrians/drivers involved in the accident, events immediately preceding the accident.
On many occasions a factor causing accidents or a countermeasure is expected to affect a particular group of accidents. If this group of accidents can not be isolated it is sometimes possible to identify a group of accidents which reflects the variation in accidents of the group of interest with sufficient sensitivity. Research on crash factors and countermeasures is in need of trajectories of persons involved and mechanisms of injury and damage. The kind of data for these stages will have to be retrieved from special data banks or collected for the purpose. In-depth accident investigations - with experts visiting the accident scene and

collecting a wide range of characteristics - is of necessity restricted to small numbers of accidents. Therefore there use is in the generation of hypotheses rather than statistical testing.

2.3. Conflict observations

The early studies using observations of conflicts or near-accidents were concerned with the safety of motorcars. The present interest for conflict observation techniques, however, is directed at the safety of pedestrians and cyclists. A special international working group is actively engaged on the subject. Here too, some general remarks will be made.

Conflict observation techniques are intended to measure traffic safety under a diversity of sitations for a diversity of problems on a short term.

The above mentioned working group has suggested the following definition of a conflict (Cooper, 1977):

"A traffic conflict is an observable situation in which two or more road users approach each other in space and time to such an extent that there is a risk of collision if their movements remain unchanged."

This definition seems to be restrictive on the one hand in the sense that it excludes situations with a potential for single vehicle accidents. On the other hand it looks too broad since the risk of collision has not been specified.

Some elements can frequently be found with the techniques that are used: human observers; working definiton of a conflict based on the notion of proximity (as inferred from direction and speed of movement and distance) and/or sudden reaction (as inferred from change in direction or speed of movement); classification of conflicts based on manoeuvre and traffic modes and on seriousness.

The techniques offer the opportunity to record all kinds of characteristics for each conflict. As well as there are many more light accidents than serious accidents there are many more conflicts than light accidents. This implies that the ratio between number of conflicts and accidents may vary together with characteristics of the

situation and conditions. For this reason a weighted sum of different classes of conflicts is used in more sophisticated conflict observation techniques.
Future research will have to show how closely the number of conflicts is correlated with the number of accidents in a variety of situations and conditions. For the moment it can be stated as a general rule that the closer the traffic situations resemble each other the more alike will be the ratios between number of conflicts and accidents.

For the time being the use of conflict observations is limited because the question on the stability of the ratio between number of conflicts and accidents has not yet been answered satisfactorily and because the method is costly as a consequence of the manpower needed.

2.4. Feelings of safety

Insofar as feelings of safety of road users or residents are used as a substitute for accidents to measure safety, this is based on the idea that these persons are very close to the traffic scene. This would mean that they experience the amount of safety of such a traffic scene more quickly and accurately than the official recording systems. A further argument in favour of the use of what is called "subjective safety" is the opportunity this method offers to measure the safety of particular small groups of traffic situations, areas or groups of road users. Accidents will have to be collected over large groups or areas. Statements based on accidents cannot give account of variations within these groups.
A number of arguments against the use of "subjective safety" as a replacement of objective safety can be raised. The accidents which the road users/residents are aware of will mostly be light accidents or even near-accidents. Certain types of accidents will be more emotionally appealing than others, depending on the consequences such as a fire or drowning. Whereas objective safety is based on number of accidents related to exposure it is unknown if and how this is done by road users/residents. It is not unlikely that state-

ments on safety are biased by other feelings concerning traffic such as the more general concept of traffic hindrance or - even more general - feelings of well-being as related to physical environment. It is also known that certain stimuli automatically evoke feelings of anxiety with children, which is the case for loud noise, sudden changes or the appearance of large objects in the field of view. The notion of psychological priority - indicating the tendency to give way to road user who are bigger or faster - may well be looked upon as a remainder of such primary reactions. According to this way of thinking pedestrian crossings and residential areas where psychological priority is deliberately overruled will automatically evoke feelings of anxiety with no relation to objective safety.

Finally there will be an inverse relation between feelings of safety and objective safety when feelings of lack of safety cause people to take precautionary measures (such as accompanying children; staying at home of older people) or when a feeling of safety gives rise to a lower level of attention or the acceptance of new risks (which is predicted by the theory of risk compensation).

For all these reasons it is adviseable not to use subjective safety as a substitute for objective safety.

2.5. Behaviour observations

Behaviour observations as a substitute for accidents are mostly used at the stages of countermeasure development and evaluation. This is on condition that there is sufficient empirical or theoretical knowledge to accept a relation between observed behaviour and accidents. This knowledge is mostly specific to the countermeasure at hand. The behaviour to be observed is therefore specific too. As a consequence there is no general method of behaviour observations to measure traffic safety.

Countermeasures like police enforcement and mass media campaigns are aimed at modifying behaviour. The evaluation of these countermeasures can therefore be based on behaviour observations. However, in quite a number of cases the relation between behaviour and accident risk is hypothetical. Evaluation of safety countermeasures based on behaviour observations should be followed by evaluation based on accident data, whenever possible.

3. MEASURING EXPOSURE

3.1. Introduction

Very often accidents are related to some measure of exposure. The measures in use vary widely and the objective of using such measures can be seldom found.
The resulting accident rates can be used in different ways.
1. In research on accident causation or countermeasure evaluation exposure is used to serve as a correction for the proportion of accidents that can be attributed to differences in exposure. In this way exposure is a measure for the number of risk situations. Travel distance is used as such. The assumption to be made here is that with nothing else changing but travel distance the number of risk situations (and thus the number of accidents) will be directly proportional to the travel distance. For accidents between two groups of road users it can be assumed that the number of accidents is directly proportional to the product of the travel distances of both groups. The validity of these assumptions will be discussed in para. 3.3.
At the stages of selection of problem areas and the description and analysis of problems it is not unusual to have a crude measure of exposure or none at all (e.g. population size, number of vehicles). This needs not be a drawback as long as it results in indications of variation in accident risk.

2. Exposure can also be used to produce accident rates which are relevant from a policy point of view. From such a point of view it may e.g. be relevant to know if the accident risk for one part of the population differs from that of another part, regardless of the kind and amount of travel of these parts. Population size may thus be a crude measure of exposure for one objective and provide the relevant information for another objective. The matter is complicated still further because population size may be a crude measure of exposure for policy making as well.

As a consequence of this situation it is not uncommon to find a list of alternative accident rates for the same problem. This is illustrated in Table 1 and 2. Table 1 gives three types of accident rates for residential streets (Pfundt et al., 1975); Table 2 presents six types of accident rates for residential areas (TRRL, 1977).

3.2. Exposure of pedestrians and cyclists

The use of population size as a crude measure of exposure is illustrated by the following example.
Fatalities in The Netherlands (over a period of 1974 to 1976) show a relation between municipal population and the ratio of fatalities to population (Blokpoel, 1978). For cyclists and moped riders this ratio increases the smaller the municipal population is, and is largely the result of fatalities outside built-up area. For cars this relation holds even stronger. However, it is hypothesised that in the case of cyclists and moped riders the fatalities concern mostly the local population, whereas in the case of cars this is less likely. This suggests that people living in small municipalities run (up to three times) more risk to be killed riding a bicycle or moped than inhabitants of large municipalities. For pedestrian fatalities the relation does not seem to exist, which may be explained by large numbers of pedestrians in the bigger municipalities who live in smaller municipalities. The smallest municipalities (< 10,000 inhabitants) represent almost one third on all bicycle and moped fatalities, more than three quarters of which outside built-up area. This put together looks like being reason enough for both policy makers and researchers to make this subject a priority subject.

On some occasions there is no information on exposure at all.
In such a situation the only possibility to obtain an indication of differences in accident risks is to make assumptions about relative exposure. When the distribution of accidents is strikingly different from these assumptions, this indicates a difference in accident risk. In OECD (1978) this approach was used to indicate that for bicycles and mopeds darkness has a more dangerous effect outside built-up areas than inside.

Total travel distance is a crude measure of exposure which enables a comparison of traffic modes. Table 3 is such an example (Goodwin & Hutchinson, 1975). Researchers of accident causation will attempt to explain the differences in these accident rates. For this purpose casualties should be replaced by accidents. For policy makers the inclusion of passenger casualties may be essential in which case vehicle kilometers may be replaced by occupant kilometers. It should be remembered that between traffic modes there are differences in age of road users and conditions. Not surprisingly the size of the differences and even the rank-ordering of the rates varies from country to country (OECD, 1978). A comparison of accident or casualty rates between traffic modes is thus of limited value.
Traffic mode may be further differentiated according to characteristics of pedestrian/driver, traffic situation and other conditions. Figure 1 gives relative death rates for both traffic mode and age groups (Noordzij, 1977). Pedestrians are not included. Another example is given in Table 4 A/C where pedestrians and cyclists are differentiated according to age (Wegman, 1978). In this example total travel distance is used as a measure for exposure as well as total travel time. Goodwin & Hutchinson (1975) also use this measure. For pedestrians there are problems in obtaining reliable data on travel distance and distance may not be an appropriate measure of exposure for this group.
Data on travel distance can be obtained by interviewing a population sample on travel patterns or by traffic counts on a sample of road sections. There is usually no need to have absolute measures of exposure, so that travel distance may be replaced by traffic volumes. With the first method of data collection the type of questioning and with the second method the sample of times and sites may be critical for the quality of the results. Worthwhile mentioning is the use of specially mounted cyclometers to measure bicycle kilometers (Campbell et al, 1971).

Studies on the safety of various road and traffic characteristics have made use of travel distance as a measure of exposure. Figure 2 A/B presents accident rates for the group of pedestrians, cyclists and

moped riders taken together and differentiates according to volumes of motorcars as well as type of road and speed of motorcars (Velhonoja, 1977). There is an extensive study on the effects of bicycle-tracks in which accidents rates have been calculated for road sections with or without bicycle tracks (Goldberg & Gazeres, 1962). It is stated in the report that the two types of road section are comparable on a number of aspects and in the analysis of the results no special provision is made for the traffic volume of motorcars. The authors indicate that for intersections there is no appropriate measure of bicycle exposure.
A particular attempt to correct for bicycle exposure is presented by Lott & Lott (1976). For road sections with or without bicycle lanes the distribution of accident types was compared. The distribution for road sections with bicycles lanes was corrected on the basis of the number of neutral accidents. The assumption was made that certain types of (neutral) accidents would occur regardless of the presence of bicycle lanes.

The risk of a pedestrian crossing a road has been studied with both the number of crossings (Routledge et al., 1976) and the product of pedestrian and car volume (Routledge et al., 1976; Older & Grayson, 1976) as a measure of exposure. The study by Older & Grayson compared the risk for different locations. Routledge et al. pays special attention to risk in relation to age and sex. (See also Figure 3 A/B).

Routledge et al. (1976) also discuss different methods to collect data on pedestrian exposure over an (urban) area. Actually this study concerns pedestrian crossings only. The methods are: interviewing children or parents, following children, and random site observations. The latter method has been applied by Cameron et al. (1976). In this study a detailed recording was made of the behaviour and characteristics of pedestrians as well as characteristics of the location and conditions.
Accident records provided the same variables so that for all these variables (or combinations) their relation with accident risk could be calculated (Table 5). The measure of exposure is again the product

of pedestrian and car volume. The only limitation in this study seems to be the small number of locations. One exposure study for bicycles is of similar detail, but no calculation of risk was made (Kobas & Drury, 1976).

The product of bicycle and car volume as a measure of exposure was used by Noordzij (1976). This study was aimed at the effect of darkness on bicycle safety. The available exposure data were of limited value and a number of assumptions had to be made to reach a conclusion.

The problems of selecting sites and times to collect exposure data can be solved by collecting at sites and times that are similar to those of accidents. This method was chosen by Clayton et al. (1977) who measured blood alcohol levels and other characteristics of pedestrians. Calculations give the relation between accident involvement and the presence or absence of a certain characteristic. Another study by Knoblauch (1976) has such a control group. The behaviour of both pedestrians and cars was observed. The results can be seen in Table 6 A/B.

3.3. Assumptions

Earlier in this chapter mention was made of the assumption that the number of accidents is directly linear with the total travel distance or the product of travel distances. Howarth et al. (1974) and Cameron et al. (1976) discuss a number of theoretical considerations on this subject. It can easily be seen that these assumptions can only be partly correct. Firstly, on physical grounds such a relation is to be expected for low traffic volumes only. Secondly, it is likely that the behaviour of the road users will adjust itself somehow to (the dangers associated with) the presence of other road users. This in turn will change the accident risk.

There is little empirical evidence on the relation between travel distance or the product of travel distances and accidents involving pedestrians, bicycles or mopeds.

There is no doubt about a positive relation between travel distance by pedestrians, bicycles or mopeds and accidents in which they are involved. However, Katz (1976) presents data from a number of communities in Israel which indicate that the risk for cyclists (injuries related to number of bicycles) decreases with increasing number of bicycles. Thus, the relation does not seem to be directly linear.
Table 7 shows the difference in accident rates (accidents related to travel distance) for two types of urban roads in Denmark with strongly differing volumes of car traffic (DCRSR, 1971). Pedestrians, cyclists and moped riders all show higher accident rates with higher car volumes. Figure 2 A/B, however, indicates that this relation may be linear but certainly not directly. The study from which this figure was taken concerns a particular set of Finish roads and pedestrians, cyclists and moped riders are taken as one group.
For pedestrians only Goodwin & Hutchinson (1975) have tested the relation between accidents and product of pedestrian and car volumes. The material for this study comes from a nationwide travel survey in Great Britain. The variation in product of pedestrian and car volumes is actually variation between different daylight hours of the day. On the basis of his results (Figure 4 A/B) this relation may be regarded as directly linear.
When dividing pedestrian into age groups even this would not hold according to another British study (Routledge et al., 1976). Findings indicate a greater risk (accident related to product of pedestrian and car volume) for children when crossing major urban roads. For adults there was no difference between major and minor roads.

In view of the available evidence a correction for exposure based on travel distance or the product of travel distances is to be restricted to those instances in which the range of travel distances is small.
Other solutions to the problem have been mentioned before. Goldberg & Gazeres (1962) had two groups of road sections with or without bicycle tracks that were similar in other respects (including car volume). The results of the study by Velhonoja (1977) have been presented for different car volumes. No assumption at all has to be

made when traffic volumes of both groups of road users are treated as independent variables. In the studies of Clayton et al. (1977) and Knoblauch (1976) control groups have been matched with the accident group with respect to time and sites.

TABLES 1-7

Table 1. Comparison of traffic safety of loop streets and culs-de-sac (residential streets). (Source: Pfundt, et al., 1975).

Table 2. Summary accidents rates for residential streets developed during three time periods. (Source: TRRL, 1977).

Table 3. Accident risk while travelling by different modes. (Source: Goodwin & Hutchinson, 1975).

Table 4A. Traffic mortality for pedestrians and cyclists for three age groups (1974 en 1975). (Source: Wegman, 1978).

Table 4B. Time and travel distance per day of pedestrians and cyclists. (Source: Wegman, 1978).

Table 4C. Relative risks of pedestrians and cyclists for three age groups. (Source: Wegman, 1978).

Table 5. Variation in accident risk by each variable singly, plus significance of difference from overall risk shown as H (high) or L (low). (Source: Cameron et al., 1976).

Table 6A. Pedestrian Action. (Accident and Baserate Data Compared). (Source: Knoblauch, 1976).

Table 6B. Vehicle Action. (Accident and Baserate Data Compared). (Source: Knoblauch, 1976).

Table 7. Number of accidents per 10^8 km travelled by different road users and classified by type of urban road. (Source: DCRSR, 1971).

Residential streets	Loop streets	Culs-de-sac
Accidents/1000 inhabitants/year		
All accidents	2.3	1.9
Accident with moving traffic only	1.1	0.6
Accidents/km road length/year		
All accidents	5.2	4.1
Accidents with moving traffic only	2.5	1.3
Accidents/10^6 motor vehicle km		
All accidents	16.2	11.5
Accidents with moving traffic only	7.6	4.0

Table 1. Comparison of traffic safety of loop streets and culs-de-sac (residential streets). (Source: Pfundt et al., 1975).

	19th Century	1919-1939	Post 1945
Accidents/km^2 of residential area	25.6	9.0	14.8
Accidents/km of road	1.5	0.7	1.1
Accidents/dwelling x 10^5	59	37	64
Accidents at junctions (per cent)	65	65	53
Accidents/population (thousand)	2.4	1.3	1.9
Child accidents/child (thousand)	4.2	2.3	2.3

Table 2. Summary accidents rates for residential streets developed during three time periods. (Source: TRRL, 1977).

Class of traveller	Rate per 100 million miles	
	Injuries	Deaths
Public Service Vehicle passengers[1]	40	0.2
Car drivers[2]	80	1.5
Pedestrians	400	14
Pedal cyclists[2]	900	16
Motor cyclists[2]	1700	28
Rail passengers[3]	10 (25)	0.2 (0.2)

[1] Figures for 1971 from Department of the Environment (1973a, b)

[2] Figures for 1971 from Department of the Environment (1973a)

[3] Figures for 1971 from Central Statistical Office (1972). They include both British Rail and London Transport. First figure is for accidents involving movements of railway vehicles, bracketed figure includes other accidents on railway premises. Possible differences in definition mean the injury rates may not be exactly comparable with those for road modes.

Table 3. Accident risk while travelling by different modes. (Source: Goodwin & Hutchinson, 1975).

Age group	Pedestrian	Cyclist
5 - 14 year	3.7	4.5
15 - 54 year	1.1	1.5
55 year and older	7.2	8.7

Table 4A. Traffic mortality for pedestrians and cyclists for three age groups (1974 and 1975). (Source: Wegman, 1978).

Age group	Pedestrian		Cyclist	
	time (min)	distance (m)	time (min)	distance (m)
5 - 14 year	20	1000	15	2000
15 - 54 year	10	700	10	2000
55 year and older	20	1300	15	2300

Table 4B. Time and travel distance per day of pedestrians and cyclists for three age groups. (Source: Wegman, 1978).

Age group	Pedestrian		Cyclist	
	time	distance	time	distance
5 - 14 year	2	2	2	3
15 - 54 year	1	1	1	1
55 year and older	3	3	4	5

Table 4C. Relative risks of pedestrians and cyclists for three age groups. (Source: Wegman, 1978).

Variable and Levels	Accidents (No.)	Exposure (%)	Estimated Relative Risk
PEDESTRIAN SEX			
Male	592	68.7	0.93 (L)
Female	337	31.3	1.16 (H)
PEDESTRIAN AGE			
0 - 4	70	0.7	11.00 (H)
5 - 10	184	5.4	3.72 (H)
11 - 20	153	18.2	0.92
21 - 40	164	53.7	0.34 (L)
41 - 60	190	18.8	1.11 (H)
61 +	152	3.2	5.17 (H)
PEDESTRIAN COMPANY			
Alone	821	62.9	1.41 (H)
Accompanied	102	37.1	0.30 (L)
PEDESTRIAN MOVEMENT			
Crossing	846	91.4*	0.99
Not crossing	44	12.9*	0.36 (L)
Walking along road	38	3.1*	1.32 (H)
CROSSING/PACE			
Walking	551	85.2	0.80 (L)
Running	254	14.8	2.14 (H)
CROSSING/DIRECTION			
Ped. from left	462	50.0	1.13 (H)
Ped. from right	358	50.0	0.87 (L)
CROSSING/VISIBILITY			
From behind object	70	25.0	0.33 (L)
Not behind object	776	75.0	1.22 (H)
CROSSING/BOARDING			
To or from bus	13	0.9	1.70 (H)
To or from other vehicle	5	2.1	0.28 (L)
Not boarding	828	97.0	1.01
WALKING ALONG ROAD			
With traffic	33	36.6	2.37 (H)
Against traffic	5	63.4	0.21 (L)
VEHICLE TYPE			
Car	819	90.6	1.00
Truck	32	6.1	0.58 (L)
Motorcycle	35	1.3	2.93 (H)
Bus	17	2.0	0.96
Pedal cycle	0	0.1	0.0
VEHICLE MOVEMENT			
Straight ahead	826	96.9	0.94 (L)
Turning right	56	1.2	5.23 (H)
Turning left	19	1.9	1.67 (H)

* The 3 categories of pedestrian movement were intended to be mutually exclusive, but in fact 7.4% of the pedestrians were recorded as having more than one type of pedestrian movement. Relative risks are referred to the overall accident risk for <u>any</u> pedestrian movement.

Variable and Levels	Accidents (No.)	Exposure (%)	Estimated Relative Risk
TIME OF DAY			
7- 8 am	41	5.5	0.80 (L)
8- 9 am	46	9.0	0.55 (L)
9-10 am	27	8.8	0.33 (L)
10-11 am	37	9.3	0.43 (L)
11-12 noon	39	10.4	0.40 (L)
12- 2 pm (2 hours)	65	17.8	0.39 (L)
2- 3 pm	47	6.5	0.78 (L)
3- 4 pm	85	8.6	1.06
4- 5 pm	131	8.9	1.58 (H)
5- 6 pm	104	8.4	1.33 (H)
6- 7 pm	82	3.5	2.48 (H)
7- 8 pm	54	1.2	4.92 (H)
8-10 pm (2 hours)	85	1.6	5.91 (H)
10- 1 am (3 hours)	88	0.5	17.49 (H)
DAY OF WEEK			
Monday-Thursday	508	65.3	0.83 (L)
Friday	195	16.5	1.27 (H)
Saturday	159	15.3	1.12
Sunday	69	2.8	2.65 (H)
LOCATION WITH RESPECT TO INTERSECTION			
At intersection	409	37.7	1.17 (H)
30-100 feet from intersection	136	29.6	0.50 (L)
More than 100 feet from intersection	383	32.7	1.26 (H)
LOCATION WITH RESPECT TO TRAFFIC CONTROL			
With signal lights	42	16.7	0.27 (L)
Against signal lights	19	0.4	5.45 (H)
At other pedestrian crossing	150	9.1	1.77 (H)
Within 100 feet of any ped. crossing	19	3.9	0.52 (L)
More than 100 feet from ped. crossing	696	69.9	1.08 (H)

Table 5. Variation in accident risk by each variable singly, plus significance of difference from overall risk shown as H (high) or L (low). (Source: Cameron et al., 1976).

Pedestrian Action	Accident Data %	Baserate Data %	Hazard index More Hazardous
Standing in roadway	8.1	1.5	5.4
Coming from behind parked vehicle	5.3	1.1	4.8
Working in roadway	2.2	0.8	2.8
Working on vehicle	3.5	1.8	1.9
Crossing not at intersection	39.4	27.0	1.5
Walking in road, with traffic	10.8	12.3	0.9
Playing in road	3.6	4.9	0.7
Walking in road, against traffic	4.8	8.0	0.6
Crossing at intersection	18.3	29.0	0.6
Getting on/off school bus	1.6	3.6	0.4
Getting on/off other vehicle	2.4	9.9	0.2

Table 6A. Pedestrian Action. (Accident and Baserate Data Compared). (Source: Knoblauch, 1976).

Vehicle Action	Accident Data %	Baserate Data %	Hazard index More Hazardous
Out of control	2.7	0.0	
Backing up	3.0	0.1	30
Passing	2.5	0.1	25
Other	3.6	0.2	18
Starting in roadway	1.9	0.5	3.8
Changing lanes	1.2	0.4	3.0
Going straight ahead	77.2	85.1	0.9
Turning right	2.3	5.1	0.5
Turning left	2.2	5.2	0.4

Table 6B. Vehicle Action. (Accident and Baserate Data Compared). (Source: Knoblauch, 1976).

Streets	Cyclists	Moped Riders	Pedestrians
Urban arterials	4.2	8.9	4.0
Other urban streets with less traffic	2.0	5.5	1.2

Table 7. Number of accidents per 10^8 km travelled by different road users and classified by type of urban road. (Source: DCRSR, 1971).

FIGURES 1-4

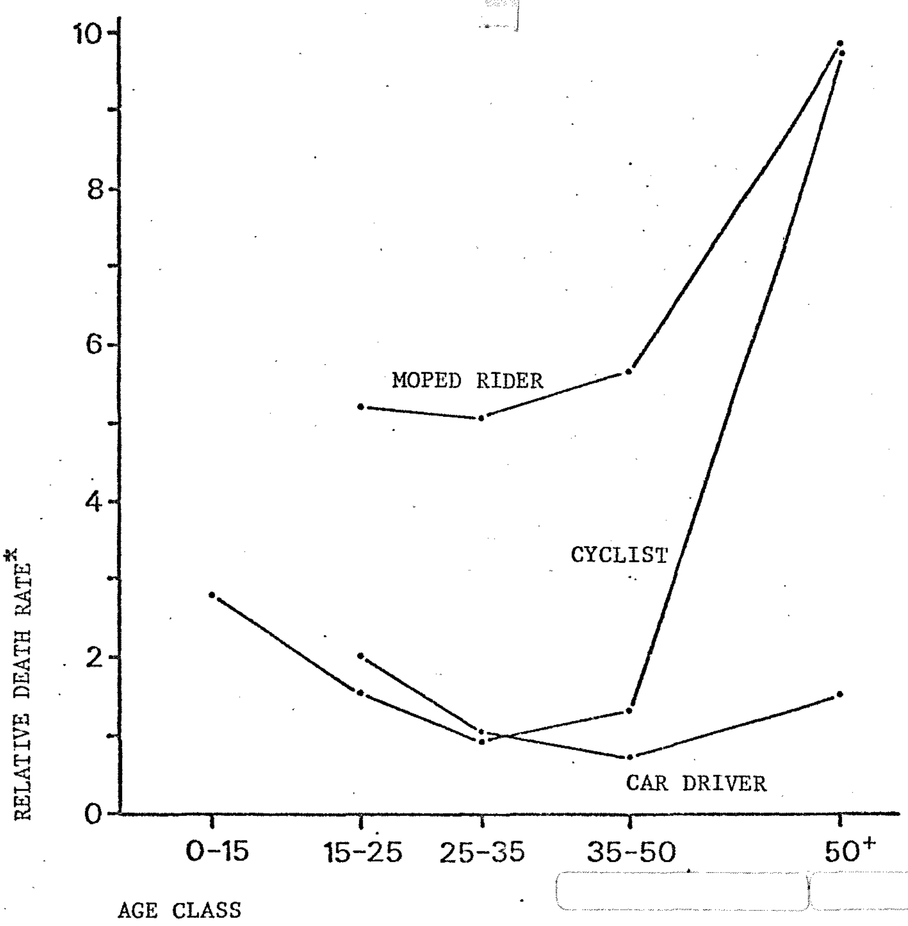
Figure 1. Relative death rates of cyclists, moped riders and car drivers for different age classes in The Netherlands in 1976 (deaths related to travel distance). (Source: Noordzij, 1977).

Figure 2. The dependance of the accident rate of light traffic on the volume and speed of the motor vehicle traffic. (Source: Velhonoja, 1977).

Figure 3A. The risk per road crossing (p_{ar}) for male and female children aged 5-10 years, with Standard Errors. (Source: Howarth, 1974).

Figure 3B. The risk per encounter with a car ($p_{a/c}$) for male and female children aged 5-10 years, with Standard Errors. (Source: Howarth, 1974).

Figure 4. Relation between accidents and the product of vehicle and pedestrian flows for daylight hours. (Source: Goodwin & Hutchinson, 1975).



* death rate of car drivers 25-35 years = 1

Figure 1. Relative death rates of cyclists, moped riders and car drivers for different age classes in The Netherlands in 1976 (deaths related to travel distance). (Source: Noordzij, 1977).

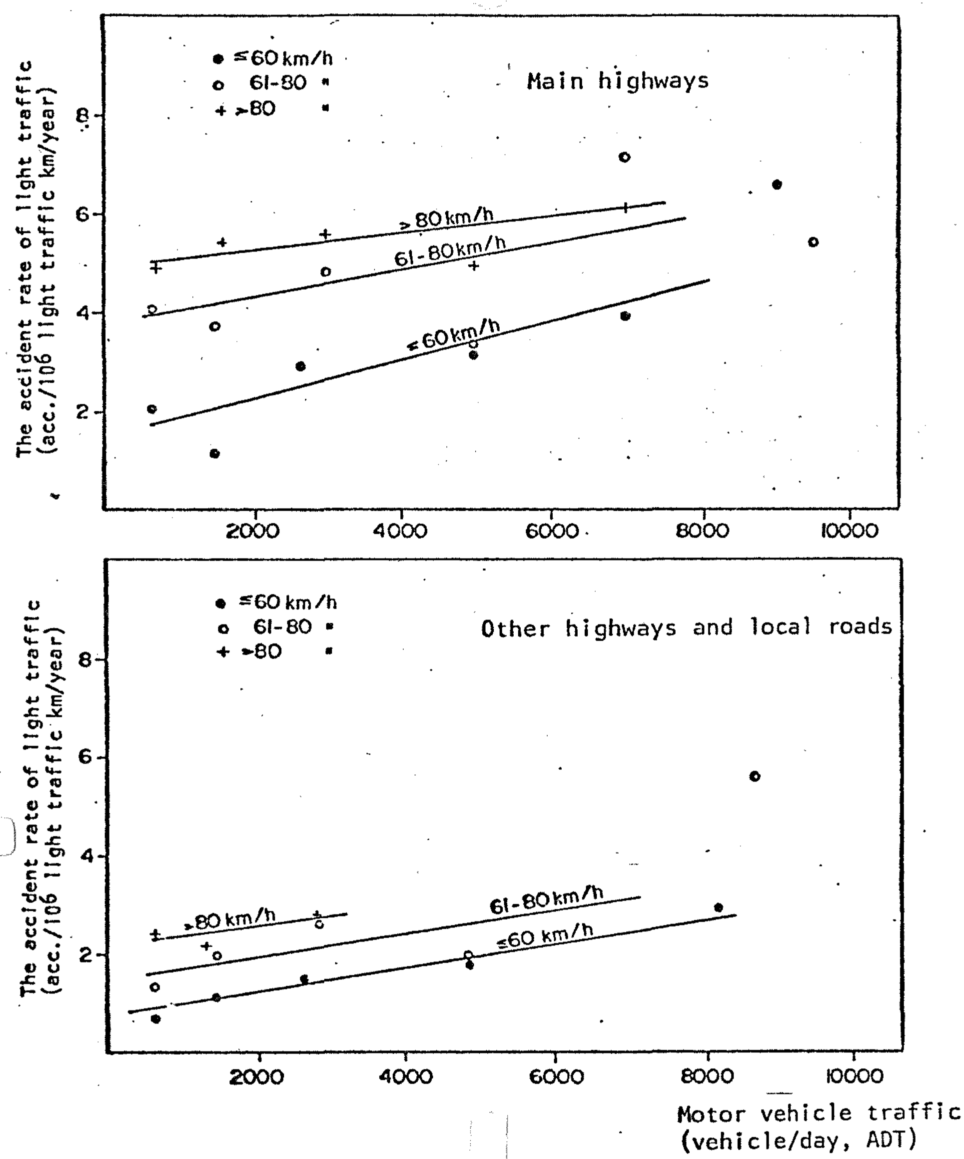


Figure 2. The dependance of the accident rate of light traffic on the volume and speed of the motor vehicle traffic. (Source: Velhonoja, 1977).

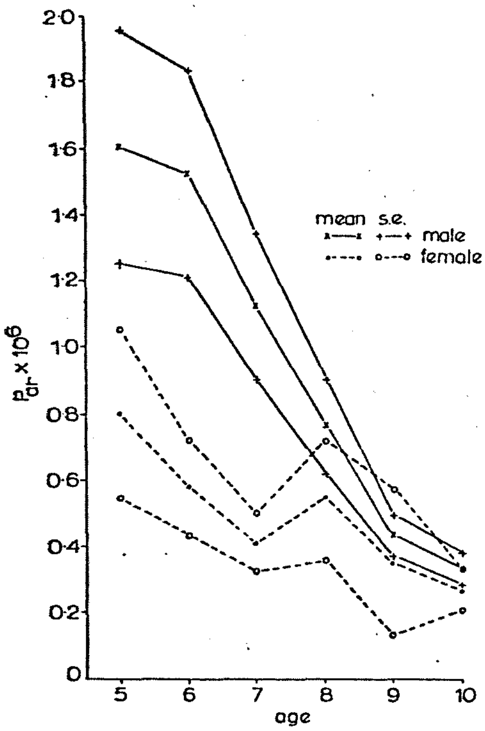


Figure 3A. The risk per road crossing (p_{ar}) for male and female children aged 5-10 years with Standard Errors. (Source: Howarth, 1974).

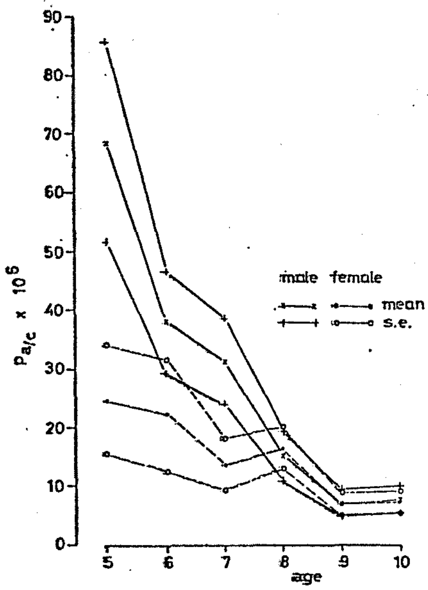


Figure 3B. The risk per encounter with a car ($p_{a/c}$) for male and female children aged 5-10 years with Standard Errors. (Source: Howarth, 1974).

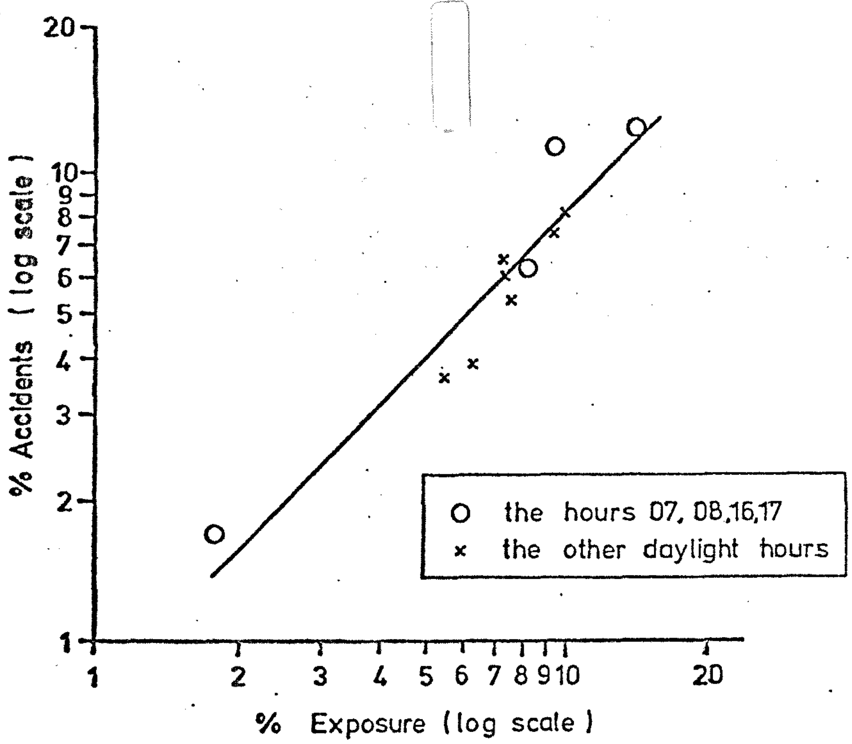


Figure 4. Relation between accidents and the product of vehicle and pedestrian flows for daylight hours. (Source: Goodwin & Hutchinson, 1975).

REFERENCES

Blokpoel, A. (1978). De verkeersonveiligheid van voetgangers, fietsers en bromfietsers binnen de bebouwde kom in cijfers. (Road safety of pedestrians, cyclists and moped riders inside built-up areas in figures). SWOV, Voorburg, 1978. (Only in Dutch).

Cameron, M.H. et al. (1976). Pedestrian accidents and exposure in Australia. In: Hakkert, A.S. (ed.) 1976, pp. 1B1-1B10.

Campbell, B. et al. (1971). Bicycle riding and accidents among youths. Univ. of North Carolina, Chapel Hill, 1971.

Carroll, P.S. (1973). Classifications of driving exposure and accident rates for highway safety analysis. Accid. Anal. & Prev. 5 (1973) 2: 81-94.

Clayton, A.B. et al. (1977). A controlled study of the role of alcohol in fatal adult pedestrian accidents. In: Proc. of the 7th International Conference on Alcohol, Drugs and Traffic Safety, Melbourne, 1977. (In press).

Cooper, P. (1977). Report from group discussions; Group C. In: Proceedings: First workshop on Traffic Conflicts, pp. 132-136. TØI, Oslo/LTH, Lund, 1977.

DCRSR (Danish Council for Road Safety Research) (1971). Accident rates in different street categories. Research memorandum 132. Copenhagen, 1971.

Goldberg, S. & Gazeres, J.-C. (1962). Les accidents sur pistes cyclables. ONSER bulletin. Arcueil, (September) 1962.

Goodwin, P.B. & Hutchinson, T.P. (1975). The risk of walking. University College London, Traffic Studies Group, London, 1975.

Hakkert, A.S. (ed.) (1976). Proceedings of the International Conference on pedestrian safety, Haifa, December 20-23, 1976, Volume 1. Michlol-Publishing House, Technon, Haifa, 1976.

Howarth, C.I. et al. (1974). An analysis of road accidents involving child pedestrians. Ergonomics 17 (1974) 3: 319-330.

Katz, A. (1976). Some characteristics of bicycle travel and accidents in towns. In: Hakkert, A.S. (ed.) (1976), pp. 3H1-3H14.

Kobas, G.V. & Drury, C.G. (1976). The bicyclist's exposure to risk. In: Proc. of the 6th Congress of the International Ergonomics Association, Univ. of Maryland, 1976, pp. 484-487.

Knoblauch, R.L. (1976). The rural/suburban pedestrian accident problem. In: Hakkert, A.S. (ed.) (1976), pp. 1E1-1E5.

Lott, D.F. & Lott, D.Y. (1976). Differential effect of bicycle lanes on ten classes of bicycle-automobile accidents. Transportation Research Record 605 (1976): 20-24.

Noordzij, P.C. (1976). Cycling in the dark. J. of Saf. Res. 8 (1976) 2: 73-76.

Noordzij, P.C. (1977). De (brom)fietser en de verkeersveiligheid. (The cyclist and moped rider and road safety). SWOV, Voorburg, 1977. (Only in Dutch).

OECD (1978). Safety of two-wheelers. OECD, Paris, 1978.

Older, S.J. & Grayson, G.B. (1976). An international comparison of pedestrian risk in four cities. In: Hakkert, A.S. (ed.) (1976), pp. 1A1-1A7.

Pfundt, K. et al. (1975). Verkehrssicherheit neuer Wohngebiete. HUK-Verband, Köln, 1975.

Routledge, D.A. et al. (1976). Four techniques for measuring the exposure of young children to accident risk as pedestrians. In: Hakkert, A.S. (ed.) (1976), pp. 7B1-7B7.

TRRL (Transport and Road Research Laboratory) (1977). Road accidents in residential areas. TRRL Leaflet LF 650. TRRL, Crowthorne, 1977.

Velhonoja, P. (1977). The effect of road and traffic conditions on light traffic accidents. The National Board of Public Roads and Waterways, Road Design Office, Helsinki, 1977.

Wegman, F.C.M. (1978). Verkeersonveiligheid bij kinderen. (Road safety of children). SWOV, Voorburg, 1978. (Only in Dutch).