PEDESTRIAN SAFETY

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1. INTRODUCTION

The safety of pedestrians is a major concern for policymakers in most countries, as a great number of pedestrians are involved in road traffic accidents.
Apart from the direct effects of accidents also indirect effects may occur, such as the frustration as a result of the expectation, or rather the fear, of being involved in an accident: aged people do not dare to go outdoors; parents have to bring their children to the (nearest) school. These indirect results became increasingly in the focus of attention recently; concepts like subjective danger and amenity are used for this. Presently, these concepts cannot be quantified. Only where the influence is known of these feelings of unsafety on the life pattern, and on the traffic behaviour, one may look for indicators of these concepts.

The results of accidents expressed in terms of injury and damage are quite well known. Usually this is called: objective unsafety. Such data can be used as well to indicate the traffic risk, i.e. the probability to sustain damage as a result of traffic accidents. For this, we must know the relationship between accident data and the measure of being exposed to the traffic: exposure data. It is necessary to known whether a certain high risk to die in a certain type of accidents is a result of a high degree of accident involvement or of a high chance to die of the sustained injuries (SWOV, 1981, p. 3-4).

2. PEDESTRIAN ACCIDENTS

In order to have an idea about the danger for pedestrians, usually the number of inhabitants is taken as a measure of "exposure". Thus, in many cases pedestrian accidents are expressed in "...... per 100,000 inhabitants". For vehicle accidents a more appropriate measure of exposure is the unit of travel ("...... per 10^6 vehicle km").
In Figure 1 the data are given for the total number of fatalities in traffic through the years, split up after the mode of transportation. Figure 2 gives a relative comparison of a number of causes of death. From these figures, both for the Netherlands, it can be seen that the road traffic is a very important cause of death, that passenger cars play the predominant role, and that in recent years the number of fatalities is sharply decreasing. A similar trend may be observed for most of the Western-European countries (Figure 3).
From Figure 1, and also from Figures 4 and 5 it can be seen that both in absolute values, in index numbers and in relation to the grand total of road accidents, the pedestrian accidents gradually decrease in number - at least in the Netherlands. The absolute numbers, however, are still much too large.
This dramatic aspect is even enhanced further when Figure 6 is considered. Here, the age distribution is given for different modes of traffic participation (for the Netherlands, for 1978/1979). The graph is built up as follows: per age-group of five years each, the total of 100% is subdivided over the different modes.
So, of all persons between 5 and 10 years of age killed in traffic, nearly 50% are killed while they took part in traffic as pedestrians, 35% as pedal cyclists, 15% as passengers in cars etc. For pedestrians the very marked peaks at very high and very low ages should be noted. The victims are predominantly the children ant the elderly. This fact remains, even if one considers that most probably the major exposure of these age groups is also as pedestrians. This holds for fatalities. If one considers the injury accidents - which are not accurately reported in the Netherlands - one may expect that the situation is relatively speaking even more unfavourable for the young, as on the average more injury accidents per fatality are reported for children in comparison to the elderly. This is shown in Figure 7.

So we may conclude that children are the most important group of traffic-accident victims when we consider the pedestrians. This is stated here for the Netherlands, but similar findings are reported in other countries as well (OECD, 1970).
This predominance of the younger persons as victims in pedestrian accidents is not found in the dark. In the dark the percentage of traffic accidents, and particularly fatalities that involve pedestrians, is very high. However, it is predominantly the adult and the elderly age groups that suffer. This is illustrated in the Tables 1 and 2 (after OECD, 1980). Table 3 shows the same, but it shows also that a large number of fatal pedestrian accidents in the dark happen on unlit roads. As in the Netherlands nearly all urban roads are lit, this implies that those accidents have happened outside built-up areas.
A final aspect of the pedestrian accidents we will mention here is the classification of the "other" party. It follows from Table 4 that most people die in traffic when they travel in cars. This group counts at least 45%. But it follows as well that the car is the major "other" party for fatal pedestrian accidents. It amounts to 9% of all fatal accidents. One may add to this 2% for accidents with trucks and another 2% for complex accidents that are likely to include cars as well. So in the great majority of cases the fatal pedestrian accidents involve cars and trucks.

3. COUNTERMEASURES

The occurrence and the severity of pedestrian accidents call for countermeasures; four types are commonly in use.

1. Countermeasures aimed at avoiding the possibility of conflicts between pedestrians and motorized traffic.

These countermeasures focus on the separation of traffic modes; either in general or localized at pedestrian crossing facilities.

2. Countermeasures aimed at reducing the risk for severe conflicts.

These countermeasures focus on improving the visibility of the parties involved, particularly the visibility of the pedestrians. Two main groups can be discerned: installing public lighting, or improving conspicuity both of pedestrians and vehicles.

3. Countermeasures aimed at reducing the severity of the results for those cases where accidents have not (could not) been avoided. These countermeasures focus on the shaping of the exterior of vehicles.

4. Countermeasures aimed at improving the situation in general.

Many of these countermeasures aim at educating or training the road users, particularly the (young) pedestrians. Propaganda and enforcement of traffic regulations may be included here.

In the following, a number of these countermeasures will be discussed in some detail. Emphasis will be placed on those countermeasures that are particularly of interest for the night-time situation.

One final remark. In a number of countries the idea of improving the residential regions has become important issue in traffic policy and planning. These ideas - such as the "woonerf"-idea in the Netherlands - however, are essentially measures aimed at improving the amenity (the quality of life) in the residential areas; they are not to be considered as road-safety measures. On the other hand, it goes without saying that those measures to enhance the amenity would have to be considered as quite unsuccesful if they would result in an increase in the number of road accidents.

4. MEASURES TO ENHANCE THE VISIBILITY

4.1. Improving the conspicuity of motor vehicles

In all cases where a pedestrian plans to cross a road either at a designated pedestrian crossing or at another location, he must be certain that no vehicles are approaching too close by.
At night, the vehicles need to carry lights in order to enhance their conspicuity, even on very well lit roads.
In many countries, the use of low-beam headlights is obligatory after dark, irrespective of the presence or the quality of the overhead (public) lighting. It has been shown on the basis of quite extensive research that this measure does not provide the optimal solution, because low-beam headlights usually are too glaring to allow a precise assessment of the distance and the speed of the approaching vehicle. True, the presence of the cars is signalled quite well by low-beam headlights, but the glare diminishes the possibility to assess other characteristics that may be of greater importance for road safety. An important practical factor here is the fact - often overlooked in theoretical consideration - that most low-beam headlights are <u>not</u> correctly aimed so that in fact the glare is usually much higher than the regulations should allow (Schreuder, 1976; Lindae, 1969; Yerrell, 1971). Dirty and wet headlights may make the situation even considerably worse (Rumar, 1973).
The other extreme as regards vehicle signalling is the application of side lights. In many cases, particularly in older cars, side lights often are far too weak to ensure adequate signalling.
These two aspects directly suggest the solution of this problem: vehicle-front lights (at least on well-lit roads) should have an intensity roughly halfway between side lights and low-beam headlights. Precisely this is often proposed by national and international bodies (OECD, 1971; CIE, 1975; SWOV, 1969; Schreuder, 1976). However, for various reasons the idea has never been accepted in regulation or legislation, in spite of the fact that the advantages are obvious, and that it is quite well possible to manifacture it at a reasonable price (Sabey, 1971). This concept is to a certain extent also supported by accident studies: it has been found that accidents on normally lit

roads are about as frequent in case the use of side lights is very high or on the contrary very low. On well-lit roads the low-beam headlights are associated with more accidents (SWOV, 1969; TRRL, 1964).
These findings suggest that firstly the mixture of side lights and low-beam headlights may be a disadvantage, and secondly that the optimum value of the intensity of signalling lights is somewhere between these two extremes. The "town-beam" concept which came out of these considerations suggests an intensity of about 100 cd.

4.2. Improving the conspicuity of pedestrians

A considerable number of night-time fatal accidents involve pedestrians walking along the road. When the road lighting is inadequate or even absent this may result in a very dangerous situation. One obvious solution is to provide side-walks; however, in many rural areas this is not possible on financial grounds.
A good solution can be found in applying retroreflecting devices - not only on unlit roads but also on lighted roads during rain.
"The main problem today is not to make this equipment more effective but to succesfully encourage unprotected road-users to use them regularly. The effect of publicity campaigns to promote the use of retroreflective materials by pedestrians has been studied in Sweden. The situation resembles the efforts to increase the use of safety belts before the introduction of the imperative law. In order to reach an acceptable level of usage the retroreflectors would probably have to be made compulsory" (after OECD, 1980, p. 51).
A considerable amount of research has been made to find out the best way to apply the retroreflecting devices. The result was that, generally speaking, the best detection is found by high-intensity grade type, or by corner-cube type of reflectors. However, it was found that it seems to be more important to recognize the overall situation with the pedestrian in it, than to acquire purely a good detection. Thus, the best way to apply retroreflecting devices is in such a way that the "walking" of pedestrians is enhanced.
In this respect the location at shoe-soles, trousers or sleeves seems to be better than the location at the belt. However, most research in this area was aimed at increasing the conspicuity of (pedal) bicycles;

it remains to be seen, therefore, in how far these notions can be applied to pedestrians as well.

It is difficult to give a general indication regarding the required reflection of the retroreflectors to be used by pedestrians. As a first approximation the following calculation can give some indication:

- a good reflective material can yield 400 cd/m^2 per lux
- a normal set of low-beam lights can give some 1 lux at 25 m.

With these assumptions the luminance of the material will be (at 100 m distance) about 25 cd/m^2. This value is much higher than the luminances which are common in the night-time scene, so that a reasonable visibility of the reflector may be expected. Reflectors of the corner-cube type may yield an even higher luminance.

4.3. Lighting and marking of pedestrian crossings

Within built-up areas pedestrians run, obviously, the greatest risk when they have to cross the road. In spite of the fact that it is one of the main requirements of good public lighting to make objects of the dimensions and reflectivity of pedestrians visible (Frederiksen, 1976; NSVV, 1974/1975; CIE, 1977; Schreuder, 1970, 1975) the accident statistics show that still many pedestrians are killed. The most common solution is to allow pedestrians priority on specific areas of the road; these areas are usually indicated with a "zebra" marking. Even at day, but definitely at night, the marking with a "zebra" is not enough. It is necessary to ensure the following:

1. The approach of a zebra crossing must be indicated well ahead. This can be done by advance warning signs, and by giving the zebra a lighting with a colour different from the adjoining road lighting.
2. From closer by, the position of the zebra must be clearly visible. For this, the zebra pattern is very helpful, provided the reflection characteristics and the texture of both the black and the white parts of the zebra are well chosen, so that a clear luminance contrast between the two exists also during rain, and with different types of lighting.
3. The position, movement, and particularly the position of his head and limbs of a pedestrian on or near the zebra must be easily visible. For this, a fairly large vertical component of the illuminance at the place of the zebra is required (some 30 to 50 lux). It has been observed

that, even when the contrast between the observer and the background is not particularly large, very good visibility and more in particular recognizability of the pedestrian can easily be acquired (Caminada & van Bommel, 1980). The alternative - outlining the pedestrian as a dark silhouette against a bright background by means of high level public lighting - is less effective in this respect. However, a really poor solution is to light the zebra straight from above: the vertical component of the illuminance is very low, so that the pedestrian himself is hardly visible. Worse still: the high level lighting of the zebra which results from this scheme may easily lead the pedestrian to believe that he himself is excellently visible for the oncoming traffic.

In the Netherlands it was found that increasing the number of zebra crossings per unit of road length did not have a clear positive effect on the road safety (see Figure 8). Although this result was not in close agreement with the results of other countries (SWOV, 1974) it did lead to a trend to decrease the number of zebra crossings. In part, signal-controlled facilities have been installed instead; it was found from the same study in the Netherlands that these had a clear positive effect on the road safety (see Figure 9).

For obvious reasons, the signals both for the pedestrians and for the motorized traffic must be quite clear, but not glaring at night. For the road traffic this implies a day-time intensity of at least 200 cd in the beam centre, and of between 50 and 200 cd (preferally between 50 and 100 cd) at night. This requires of course a two-level switching possibility (see CIE, 1980 and NNI, 1973). Similar requirements are given for the pedestrian lights. Additional requirements are set up for the light distribution, the colour of the lights, the luminance uniformity and the sun phantom.

Signals of this type can be - at intersections - included in the general traffic-control system, or they can be traffic (e.g. manual) operated.

5. OTHER COUNTERMEASURES

The most effective method to avoid the conflicts between pedestrians and motor vehicles is to give them separate roads. In a way, the pedestrian crossing (the "zebra" crossing) discussed above is an example of this principle: pedestrians and vehicles are separated in time. Another way is to separate them completely in location. In the "new town" concept (such as Cumbernauld and Stevenage in the UK and the Bijlmer in the Netherlands) there is a nearly complete mode separation. This, however, can be realized only, and then with great effort, for new settlements.

In existing streets - and of course for new streets as well - a number of less far-reaching countermeasures can be indicated. Most have to do with a reduction of the motorized traffic (either reduction in volume by closing down certain streets and thus avoiding through traffic, or reduction of the speed by making bumps or curves in the road).

As indicated already the "woonerf", although it has a certain similarity, is a really different countermeasure. Although also here countermeasures are taken to reduce volume and speed of motorized traffic, the principle is integration of the motor traffic into the urban life pattern, and not segregation (Schreuder, 1979).

The basic idea is that the houses and the open space between the houses together should form "homes" for the residents to live in, not only to find shelter. The woonerf is thus primarily aimed at improving the quality of life, the amenity.

The increase in amenity is realised by four independent sets of measures.

1. Legal measures

A complete new set of regulations has been introduced. The most striking regulations are:

- authorities must comply to a number of standards before a street may become a woonerf.
- vehicles may not proceed faster than at a walking pace.
- parking is permitted only on designated places.
- fast and slow traffic (e.g. cars and pedestrians or cyclists) are equivalent: the normal rules of priority are not valid in the woonerf.

- the paved area is available for all users: all drivers and pedestrians - and children! There is no distinction between the carriageway and the sidewalk.

2. Road construction and traffic management measures

- the actual driving path is narrow (some 2 to 3 m).
- at a spacing of maximum 50 m physical and visual obstructions must be erected, which force drivers to obey the speed limit.

3. Planning measures

- the woonerf concept should not be restricted to individual streets; establishments that attract much traffic should be left outside the woonerf (hospitals, shopping centres etc.).
- the woonerf should clearly look like a woonerf; it must be clearly indicated as such.

4. Social measures

- citizen participation is considered to be an integral and essential part of the decision processes regarding the woonerf.

Although most elements of the woonerf concept are well-known and applied in many countries with positive results, it is the combination, the total concept which makes the woonerf an outstanding new development.

Crash aspects of pedestrian safety can also be mentioned. It is generally accepted that cars ought to be designed in such a way as to minimize the injury for pedestrians in case of a collision. However, in most cases this approach is limited to separate countermeasures, which are not in total very effective. There is always the risk that a countermeasure that is an advantage for a certain type of collision (e.g. with cyclist) can result in an increase of the injury risk or severity for another type of collision (e.g. with a tall pedestrian). A system approach is clearly needed (see e.g. Silverleaf, 1981).

Education, training and propaganda are another group of import pedestrian-accident countermeasures.
Because, psychological speaking, the traffic environment is quite different from the "natural" surround, the traffic requires a long training but also socialisation on a continuous basis. Therefore,

efforts are usually aimed towards a comprehensive, integrated safety education.
Traffic education is aimed usually specially to children of the school age. Safety training includes the avoidance of certain risks and the coping with dangerous situations. Training programmes - such as improvement courses for drivers - differ from education programmes in that they are short-term programmes, and use clearly defined learning steps.
Finally, safety campaigns are widely in use. However, guidelines such as defined by the OECD (1971a) are not always employed. Each safety campaign requires precise information regarding its target group, the special safety problems of this group, the appropriate materials and media, hypotheses with respect to the expected effects, and verification by means of evaluation studies (after Kroj, 1981).

And finally, we will add some remarks regarding the possible advantageous effects of law enforcement, particularly as regards pedestrian safety (see also Kraay & Noordzij, 1976).

"On the whole, there is still little scientific insight into road traffic regulations and their effects on pedestrian safety. Because of their behavioural characteristics, pedestrians are difficult to influence by means of such regulations, even combined with an increased level of police supervision. This applies especially to children and elderly people.
As long as the objective and subjective chance of detection are not increased, most traffic offences will continue to fall within the "folk crime" category. If the chances of detection increases, the offender's penalty evaluation may change because being summoned "on the off chance" or "having had bad luck" will then become more common. In this case, official attention to such offences will lead to the inference that the relevant behaviour must in fact be more dangerous than had been thought.
Short infrequent campaigns are thus unlikely to improve road safety, because they hardly increase the objective chance of detection and do not lastingly change the subjective chance.
It would therefore seem worthwile in the longer term to pay more

attention to supervising pedestrian behaviour. Special attention should be paid to the relationship between pedestrian behaviour and accident risks and regarding the special and general deterrent effects."

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TABLES AND FIGURES

Fatal and injury accidents involving:	B	CDN	D(1)	F	N	NL	USA
Pedestrians							
- under 15 years	11.6	13.8	8.6	-	16.3	7.5	24.3
- 15-65 years	39.0	47.8	49.7	-	50.0	43.6	79.3
- over 65 years	31.5	34.2	33.0	-	41.6	28.9	51.0
Pedal cyclists							
- under 15 years	7.8	8.6	9.6	7.0	10.7	8.3	18.2
- 15-65 years	18.4	20.2	23.5	19.2	25.6	24.3	45.6
- over 65 years	11.0	12.7	10.4	9.1	10.5	11.6	21.0
Moped drivers							
- under 25 years	28.7	-	30.2	22.4	22.7	28.7	-
- 25-65 years	23.7	-	28.9	24.6	23.8	21.9	-
- over 65 years	20.9	-	9.4	8.2	10.4	10.2	-
Motor cyclists							
- under 25 years	32.2	34.0(2)	31.2	26.2	43.4	28.9	46.7
- 25-65 years	25.9	26.1	19.6	20.5	27.7	21.2	44.0
- over 65 years	29.7	21.0	9.1	23.2	14.2	22.2	8.3
Car drivers							
- under 25 years	39.6	50.5	42.7	36.0(3)	16.6	51.0	62.5
- 25-65 years	28.7	36.9	29.1	27.7	34.4	36.9	50.5
- over 65 years	26.8	18.3	13.7	15.6	27.0	18.0	18.4
Car occupants							
- under 25 years	40.6	47.6	-	-	21.7	44.2	58.1
- 25-65 years	33.1	39.2	-	-	41.6	37.1	50.5
- over 65 years	33.2	21.1	-	-	29.4	21.0	20.2
Commercial vehicle drivers							
- under 25 years	18.6	-	19.2	23.6	4.1	20.3	45.4
- 25-65 years	19.8	-	20.6	20.2	16.9	25.2	41.6
- over 65 years	23.2	-	12.4	12.6	16.9	-	22.6

1) 1976
2) Includes mopeds
3) Includes car-occupants

B = Belgium
CDN = Canada
D = Germany
F = France
N = Norway
NL = Netherlands
USA = United States

Table 1. Percentages of all injury accidents (including fatal accidents) occurring at night in terms of road-user category and age in 1975. (Source: OECD, 1980, Table III.3.).

Road-user category	B	CDN	D(1)	F	J	N	NL	S	USA
Pedestrians	56.5	59.5	50.4	51	54.0	46.5	37.7	56.7	59.8
Pedal cyclists	26.4	-	23.0	21	37.5	15.2	21.1	24.9	27.4
Moped drivers	42.9	-	32.5	36	38.3	26.3	34.1	16.3	-
Motor cyclists	55.4	44.4	42.0	46	42.2	24.0	43.6	40.8	45.1
Car occupants	53.6	49.7	45.9	47	63.9	43.5	42.2	40.5	54.6
Commercial vehicle drivers and others	30.6	37.3	24.7	28	47.7	13.9	22.7	27.2	47.4

1) 1976

B = Belgium
CDN = Canada
D = Germany
F = France
J = Japan
N = Norway
NL = Netherlands
S = Sweden
USA = United States

Table 2. Percentages of road-accident fatalities occurring at night in 1975. (Source: OECD, 1980, Table III.4.).

Pedestrian fatalities by age groups	Daylight	After dark dusk		Total
		Road lighting on	No road lighting	
0 to 9 years	866 94.1 47.6	37 4.0 4.7	17 1.8 5.0	920 100 31.3
10 to 19 years	106 45.3 5.8	65 27.8 8.3	63 26.9 18.6	234 100 8.0
20 to 29 years	38 32.5 2.1	45 38.5 5.8	34 29.1 10.0	117 100 4.0
30 to 39 years	30 30.9 1.7	40 42.1 5.1	27 28.4 8.0	97 100 3.3
40 to 49 years	40 32.5 2.2	47 37.6 6.0	36 28.8 10.6	123 100 4.2
50 to 59 years	75 38.3 4.1	85 43.4 10.9	36 18.4 10.6	196 100 6.7
60 to 69 years	158 42.3 8.7	168 44.9 21.6	48 12.8 14.2	374 100 12.7
70 years or older	505 57.7 27.8	292 33.4 37.5	78 8.9 23.0	875 100 29.8
Total	1818 61.9 100	779 26.5 100	339 11.5 100	2936 100 100

Table 3. Classification by age groups and lighting conditions and state of road lighting, of total numbers and percentages of pedestrian fatalities in the Netherlands in 1968-1972. (Source: SWOV, 1974.

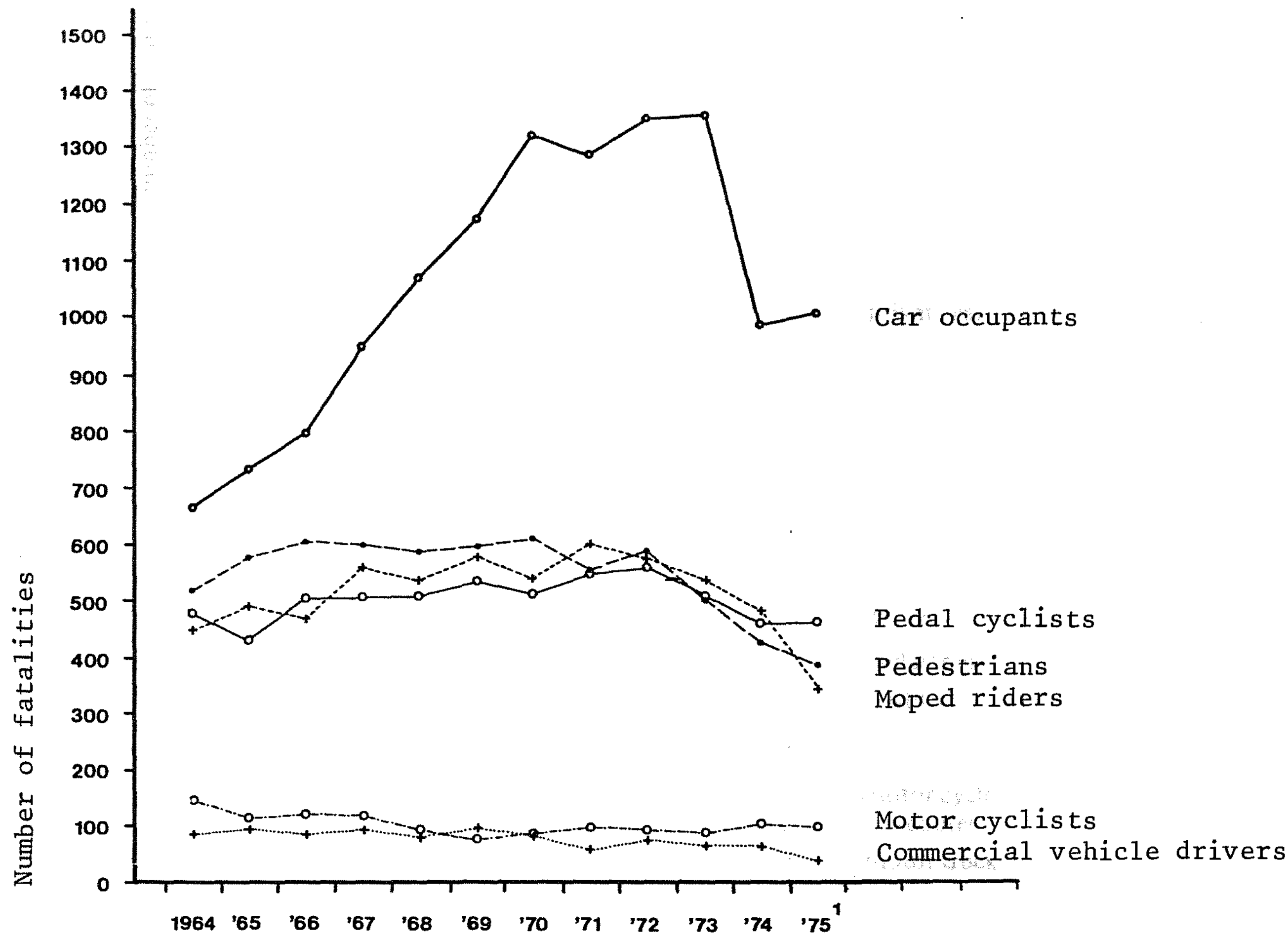
	Road-traffic fatality	Accident type	Percentage of all fatalities %	cumulative
1	car occupant	fixed object	16%	16%
2	car occupant	passenger car (other)	12%	28%
3	pedal cyclist	passenger car	11%	39%
4	pedestrian	passenger car	9%	48%
5	car occupant	commercial vehicle	7%	55%
6	car occupant	complicated accident	6%	61%
7	pedal cyclist	commercial vehicle	5%	66%
8	car occupant	single vehicle accident	4%	70%
9	moped driver	passenger car	4%	74%
10	pedestrian	commercial vehicle	2%	76%
11	moped driver	commercial vehicle	2%	78%
12	pedestrian	complicated accident	2%	80%
13	pedal cyclist	complicated accident	2%	82%
14	motor cyclist	fixed object	2%	84%
15 t/m 79	remaining 66 accident types with less than 2%		16%	100%

Table 4. Portion road-traffic fatalities in the Netherlands according to mode of traffic and accident type in 1978/79. (Source: SWOV, 1981).

Figure 7. Letality (number of deceased per 100 injured) in accidents inside built-up areas according to mode of traffic and age class. (Source: Blokpoel, 1978).

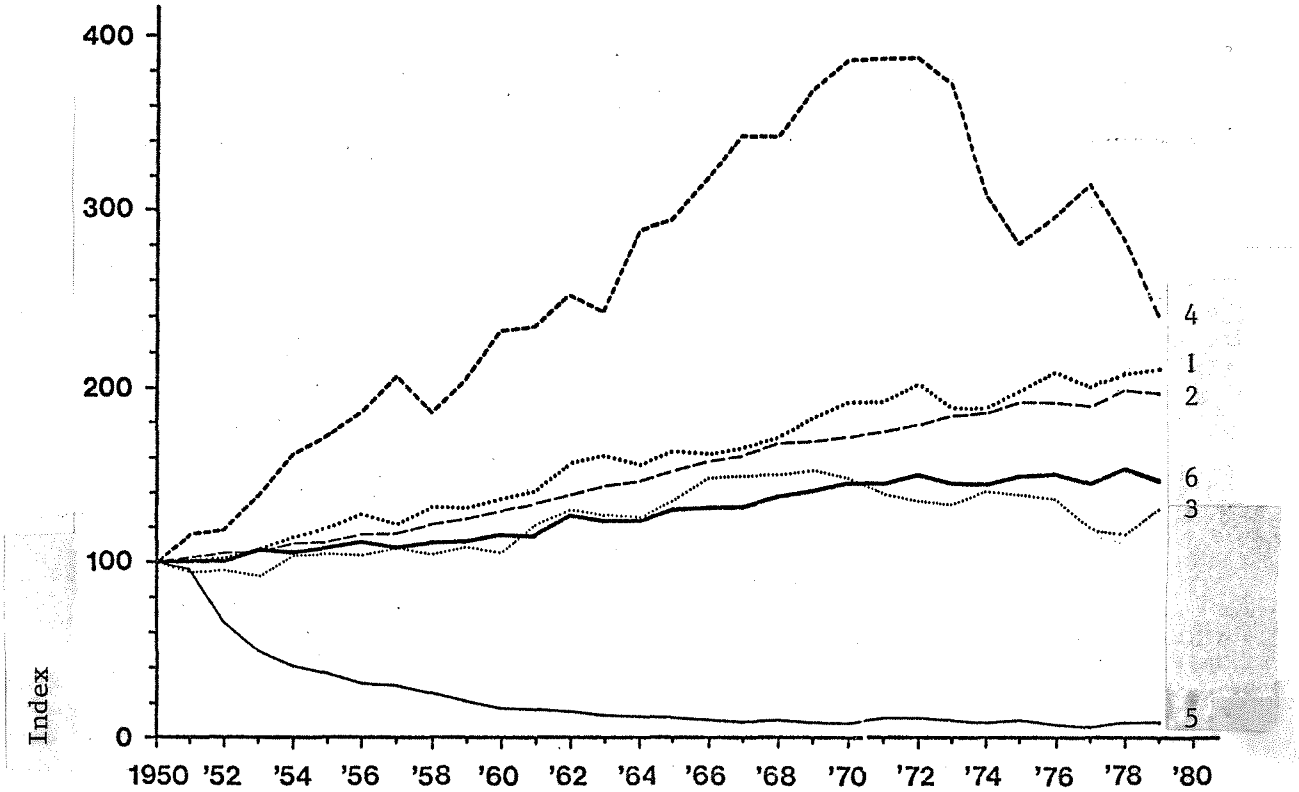
Figure 8. The Netherlands: Relationship between the numbers of zebra crossings per km of road and the relative risk. (Source: SWOV, 1974).

Figure 9. The Netherlands: Relationship between the numbers of signal controlled crossings per km of road and the relative risk. (Source: SWOV, 1974).



1) provisional figures

Figure 1. Trend in numbers of road-traffic fatalities in the Netherlands according to mode of traffic in 1964-1975. (Source: SWOV, 1978).



	1950	1979
1. Coronary & Heart	17,410 (100%)	36,782 (211%)
2. Cancer	15,410 (100%)	30,208 (197%)
3. Other accidents	2,186 (100%)	2,861 (131%)
4. Road accidents	822 (100%)	1,982 (241%)
5. TBC	1,922 (100%)	177 (9%)
6. Total	75,580 (100%)	112,565 (149%)

Figure 2. Trend in numbers of deceased persons in the Netherlands according to a number of death causes (1952 = 100). (Source: SWOV, 1981).

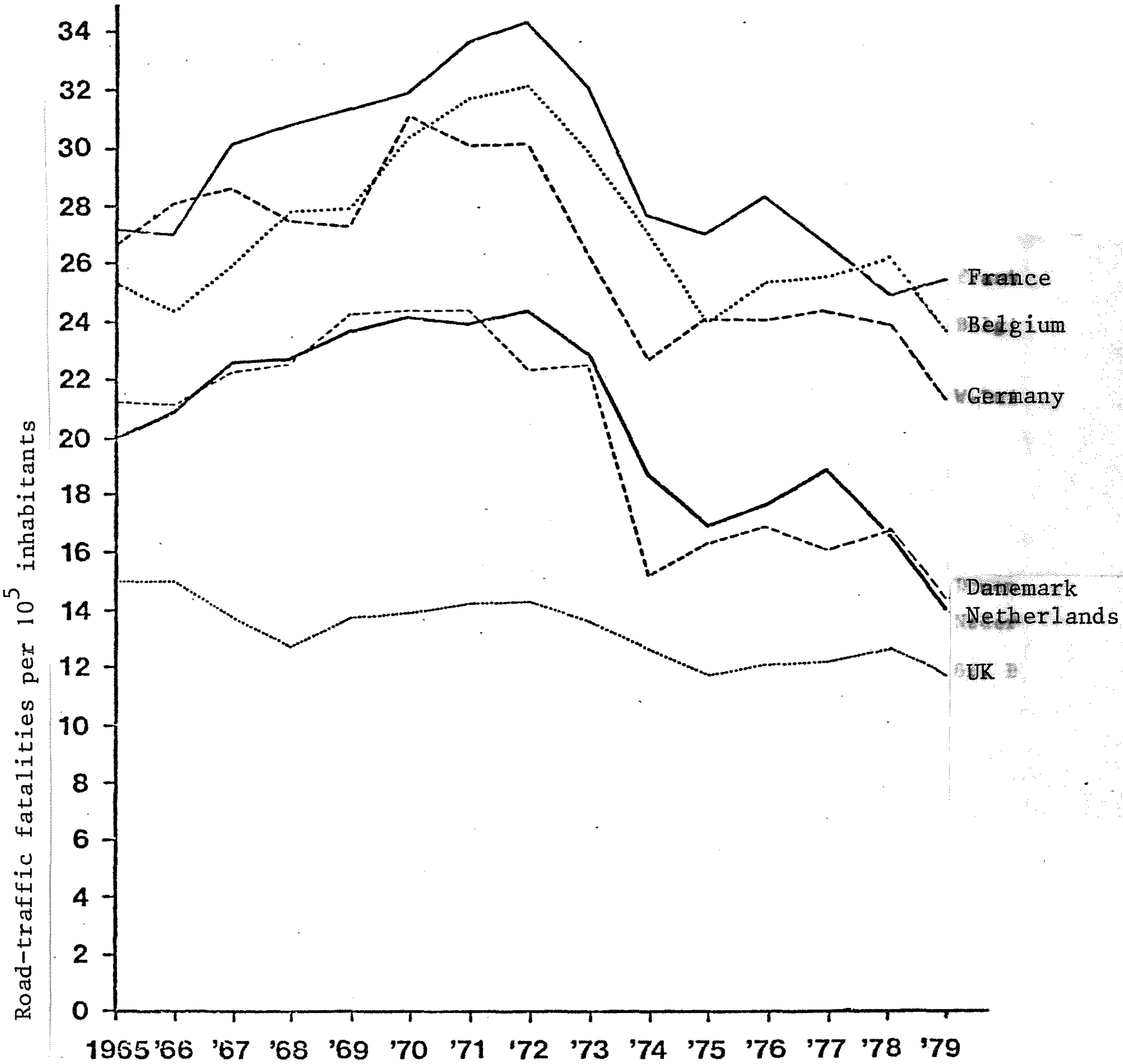
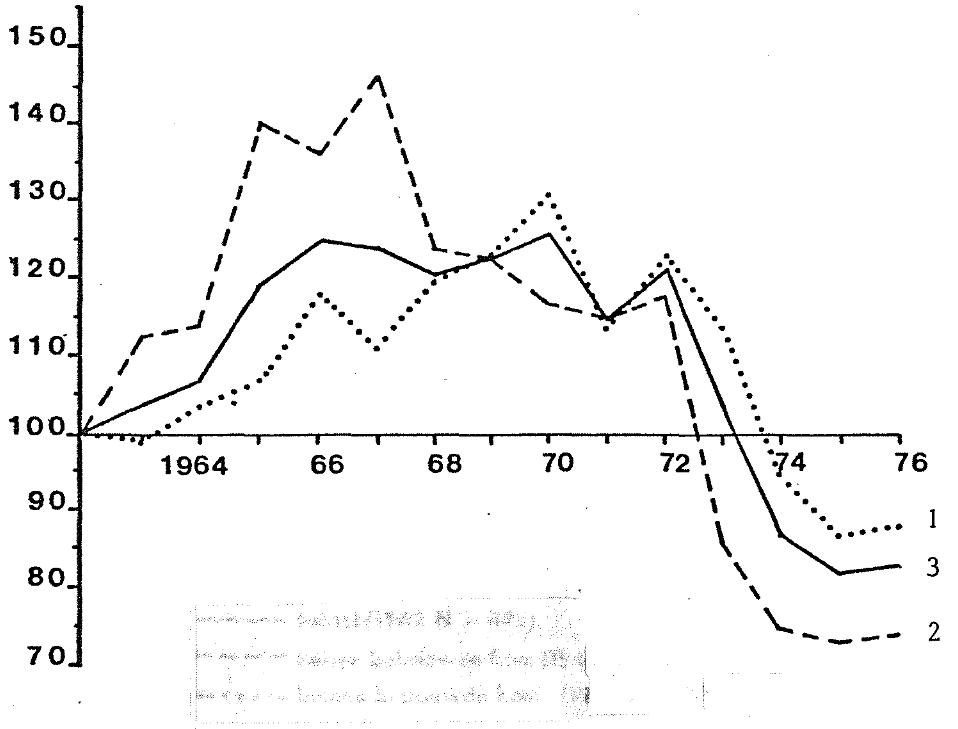
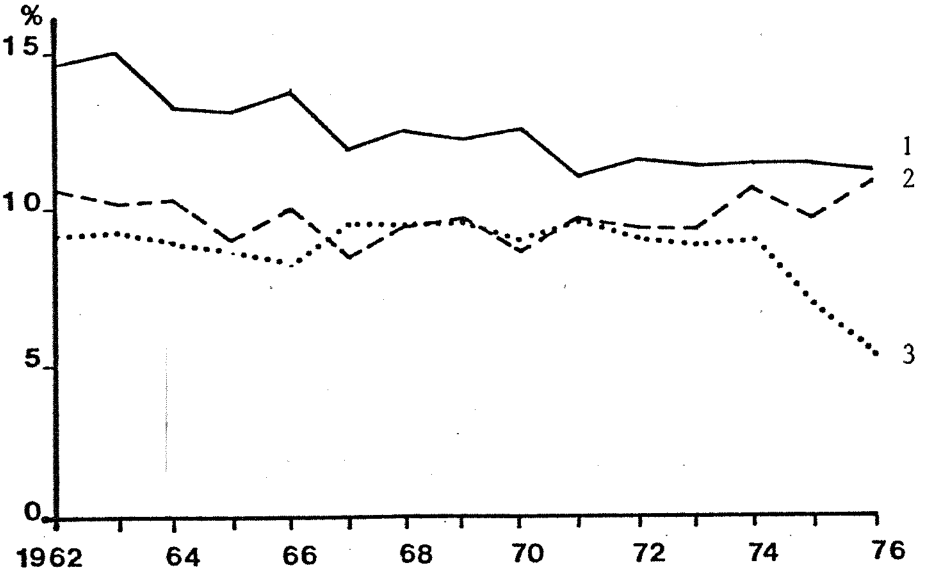


Figure 3. Trend in road-traffic fatalities per 100.000 inhabitants for a number of European countries in 1965-1979. (Source: SWOV, 1981).



1. Inside built-up areas (1962 N = 304)
2. Outside built-up areas (1962 N = 181)
3. Total (1962 N = 485)

Figure 4. Trend in pedestrian fatalities (1962 = 100). (Source: Blokpoel, 1978).



1. Pedestrians
2. Pedal cyclists
3. Moped riders

Figure 5. Trend in portion pedestrian, cyclist and moped-rider fatalities inside built-up areas in all road-traffic fatalities in 1962-1976 (Source: Blokpoel, 1978).

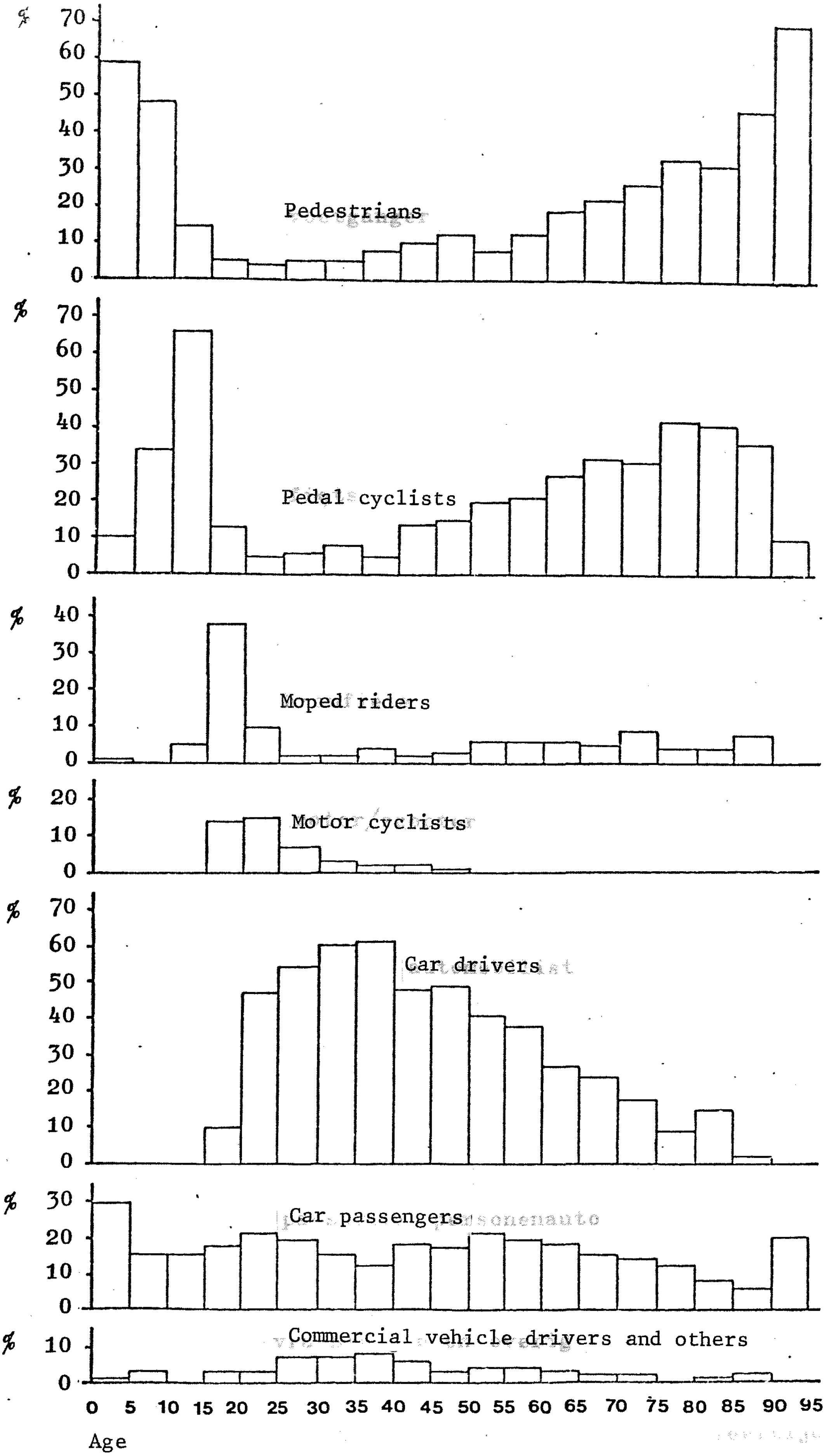


Figure 6. Portion per mode of traffic in total road-traffic fatalities per age class in 1978/79. (Source: SWOV, 1981).

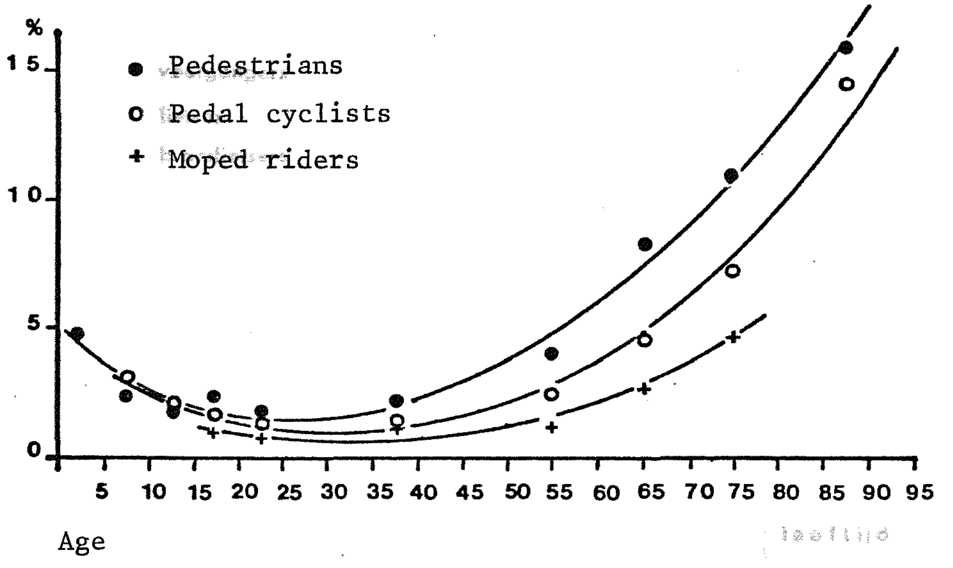


Figure 7. Letality (number of deceased per 100 injured) in accidents inside built-up areas according to mode of traffic and age class. (Source: Blokpoel, 1978).

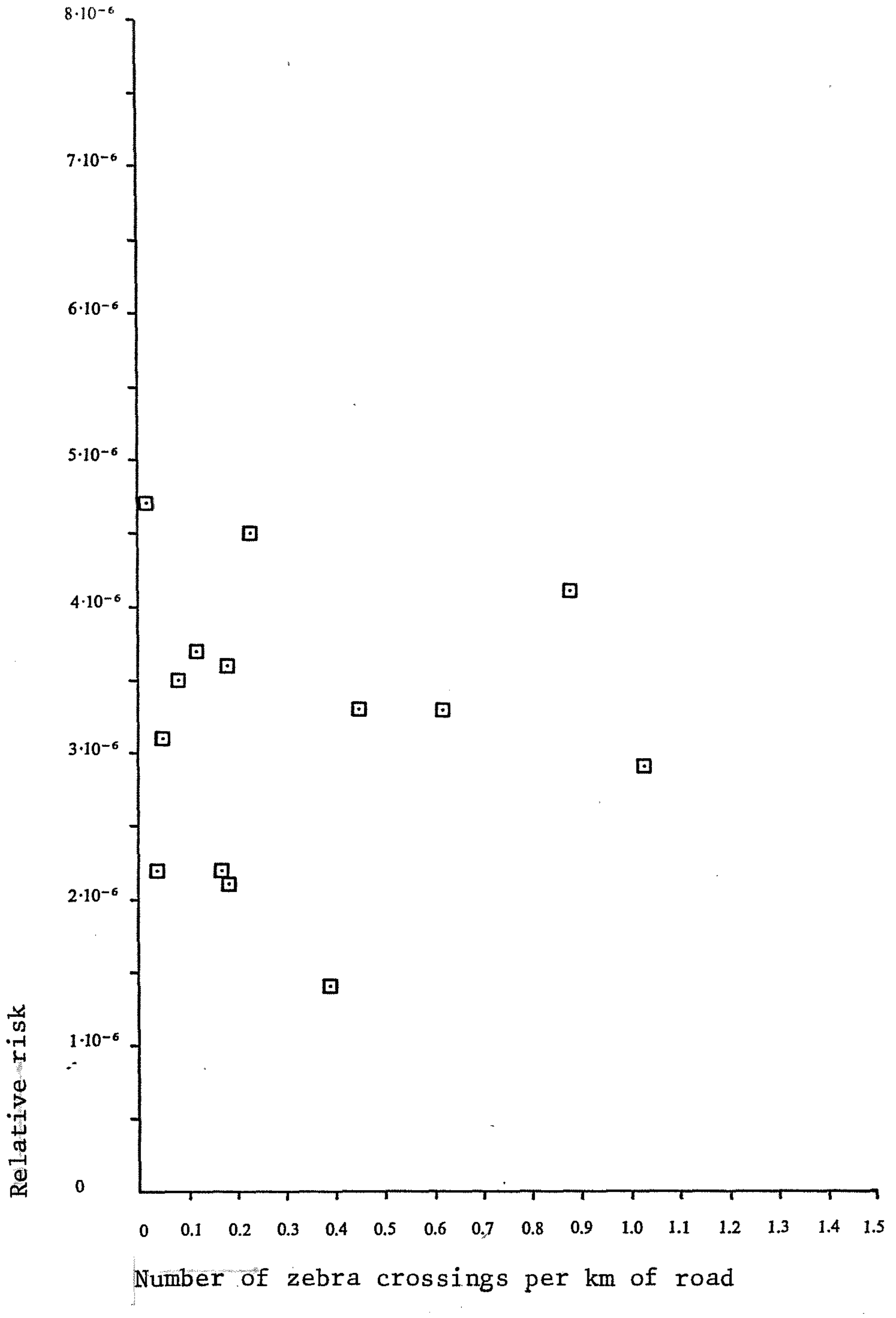


Figure 8. The Netherlands: Relationship between the numbers of zebra crossings per km of road and the relative risk. (Source: SWOV, 1974).

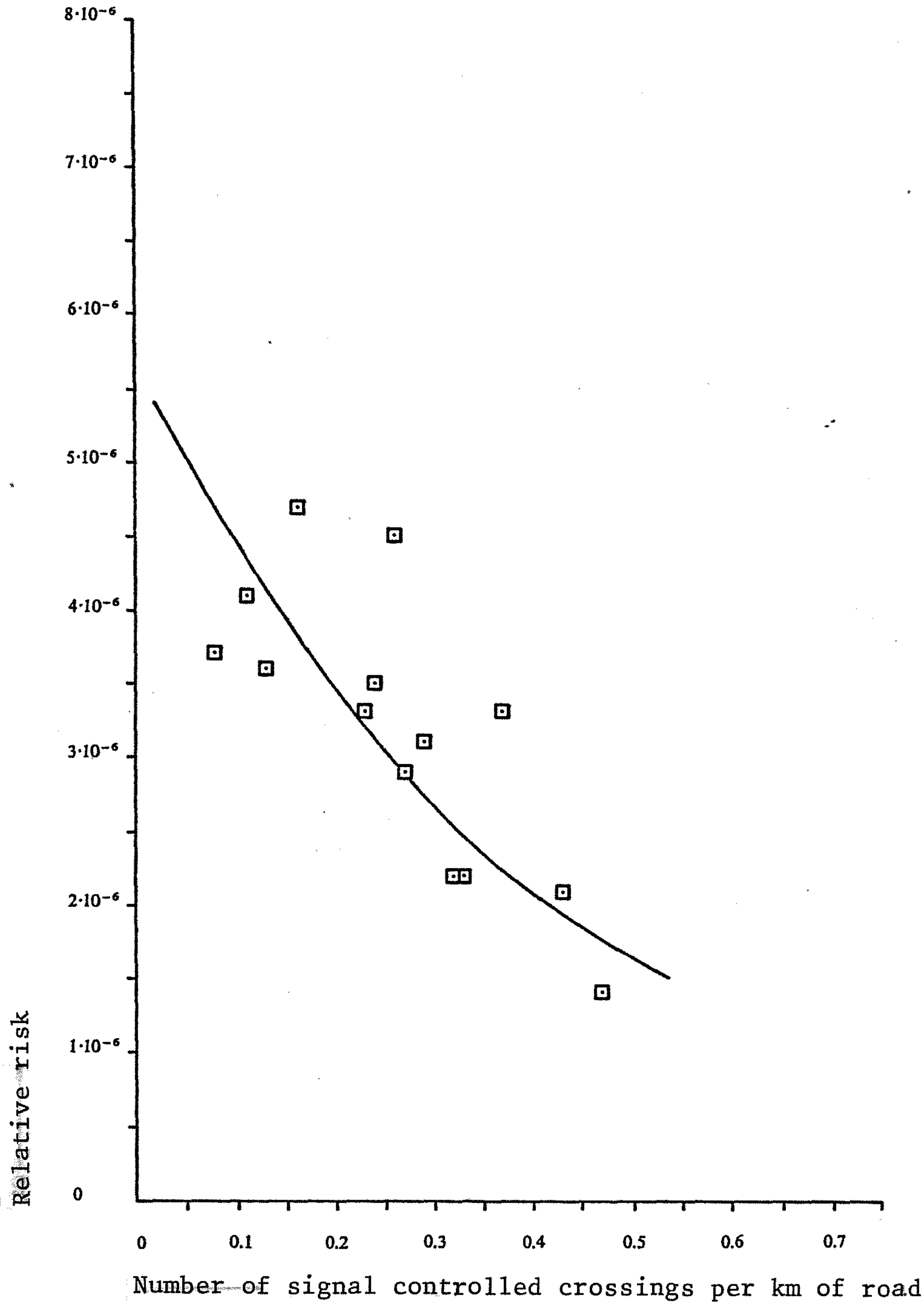


Figure 9. The Netherlands: Relationship between the numbers of signal controlled crossings per km of road and the relative risk. (Source: SWOV, 1974).