Child traffic accidents.

Epidemiological studies based upon combined hospital- and police material.

By
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Most epidemiological studies of traffic accidents are based upon material collected by the police. In several studies it has been proved, that these materials are incomplete and not representative (1). Consequently it must be of interest to base a study of child traffic accidents upon a hospital collected material, which is almost complete (5).

The material originates from Odense University Hospital which covers a population of 230.000 inhabitants (54.700 aged 0-14 years inclusive and 178.400 over 14 years per January 1st 1972). Starting February the 1st 1971 all persons hurt in accidents on public roads where wheeled traffic was involved have been registered on a special formula in the emergency ward of the hospital, approximately 3.000 persons per year. The investigation includes time and place of accident, the data and role of the victim as well as of the counterpart, and the use of protective measures. The lesions are described by type and region and are graduated into 7 groups according to expected inability in consideration of age, sex and occupation. The codified police description of type of accident is added to the formula, the information of which is then transferred to magnetic tape in the hospital's computerroom, from where it is serviceable through 22 output programmes. A more detailed description of this method is given in the IRCOBI conference proceedings 1973.

Incidence.

The increase of incidence in child traffic accidents can be seen by comparing with the result of the investigation carried out in 1959-60 in the same hospital area by P. Kølle-Jørgensen (3), see table I.

Table I.

Number of children age 0-14.	1.4.59-31.3.60.	1.4.71-31.3.72.
Injured in single bicycle accident	250	256
Pedestrian or bicyclist in collision with automobile	103	232
Injured as automobile passenger	26	96

The table shows, that during the 12-year period of investigation in which the number of children exposed in the examined age groups has increased 5%, the number of single bicycle accidents remained constant, while the number of children hit by automobiles has doubled and the number of injured automobile passengers has quadrupled.

The material has been programmed, so that it can be divided into 6 meaningful types of conflict, which simplifies the survey in comparison with the commonly used multiple classifi-

cation into means of transportation and counterpart. By "weak" road-users is understood pedestrians, bicyclists, moped riders and motorcyclists (the latter however only when in collision with larger motor vehicles). Classified as "stronger part" are automobiles and motorcyclists, provided they have collided with lighter parties. Pedestrian's single accidents have not been included in the survey.

The classification of the various age groups within the types of conflict appears in table II.

Table II.

Type of conflict.	Age 0-14	Age 15-65	Age 66-99
Single, weak	53,9	32,6	24,5
Single, strong	2,2	12,3	2,6
Weak/ weak	7,1	4,0	7,3
Weak/strong	28,7	26,2	42,7
Strong/strong	7,9	24,3	22,8
Total	100%	100%	100%

(The material dates from February 1st 1971-November 1st 1973 and comprises 1.885 persons aged 0-14 years, 5.213 aged 15-65 and 548 aged 66-99).

The children make up a relative overweight number of single weak situations (definately mostly single accidents with bicycle) and a relatively rare occurence of single strong or strong/strong situations (analogous with protected accident situations).

The incidence per 10.000 inhabitants in the age groups exposed during the investigated period of time appears in table III.

Table III.

Type of conflict.	Age 0-14	Age 15-99
Single, weak	185.7	102,9
Single, strong	7,7	36,8
Weak/weak	24,5	13,9
Weak/strong	98,9	89,9
Strong/weak	0,5	1,8
Strong/strong	27,2	78,3
Total (per 10.000)	344,5	323,6

Thus there is lower incidence of injury in protected situations and higher incidence in unprotected situations in children than in adults.

The lesions.

Characteristics in children traffic lesions have been described in several previous materials, and thus the essential interest of novelty would be a description of the lesions in relation to age and accident situations. This has been carried out by the author in a previous work (6), a short summary shall be given here.

Table IV.

	Age 0-14	Age 15-99
Head	48	37
Neck	2	4
Arms	15	17
Body	5	10
Legs	30	32
	100%	100%

(Based upon a survey of 160 injuries in children and 197 injuries in adults, all inflicted in weak/strong situations.)

Table IV shows no significant difference in the heavier regional distribution of injuries. However a significant over-

weight in number was proved of femoral fractures in relation to tibial fractures in children (10:10) compared to adults (9:28) ($P < 0,05$).

The degree of injury in children and adults respectively can be seen in table V (based upon the same material as table IV) in which light, medium or heavy lesion indicate restriction of ability in 0, 0-3 months or more than 3 months respectively.

Table V

Degree of lesion.	Age 0-14	Age 15-99
Light	63	51
Medium	34	38
Heavy	2	9
Fatal	1	2
	100%	100%

The relation between heavy/light + medium heavy lesion is significant lower in children (2:97) than in adults (9:89) ($P < 0,05$), as an indication of a better prognosis what fractures of the extremities are concerned in children.

Table VI

	160 children hit by cars	325 children in single accidents
Head	48	48
Neck	2	0
Arms	15	23
Body	5	3
Legs	30	31
	100%	100%

Table VI illustrates the regional distribution of the lesions, and table VII the degree of severity in children hit by automobiles and children fallen with a bicycle respectively. It could not be demonstrated, that there was a difference in the pattern of lesions or in the distribution of light or medium heavy injury in these children, who were referred to the casualty room. Against that, heavy or fatal lesions only occured in those hit by an automobile.

Table VII.

	160 children hit by cars	325 children in single accidents.
Degree of lesion		
Light	63	70
Medium	34	30
Heavy	2	0
Fatal	1	0
	100%	100%

In as much as the child single accidents have shown stagnant tendency and only seldom cause serious lesions, and likely are almost profylaxis resistant as well, the remaining part of the investigation will concentrate on the collision accidents.

The 24-hour, the day-of-week and the time-of-year variation in child traffic accidents.

The time-of-year variation of collisions between children

and automobiles appears in figure I, which shows maxima in the months of spring and autumn. The low number during the winter months is probably due to the fact, that children are outdoors less often then, and consequently are less exposed to collisions. The time-of-year variations are uniform what bicyclists and pedestrians are concerned. There are only few days per year with slippery roads in the area of investigation.

Figure II shows the 24-hour variation of the collision accidents at different times of the year. The 24-hour variation is uniform, and no relation to lighting conditions can be proved.

Figure III shows the everyday pattern of children's single accidents and collision accidents as well as the pattern of traffic on a medium size exit road. Figure IV shows the same relations for Saturday-Sundays where the number of accidents are added up, in as much as their relation in principal is identical.

The 24-hour pattern of accidents is uniform, independent of day-of-week or type of accident, with obvious maxima around 5 p.m., most definate what the collision accidents are concerned, while the maxima of the heavy traffic only corresponds with this on workday afternoons. The maxima of the heavy traffic during the morning hours of the workdays and Saturday noons is not reflected in the accident curve. The traffic on a medium size exit road has been chosen as an acceptable representative of the traffic intensity in the area where the children are exposed, in as much as most collisions have taken place on this type of road or on smaller suburban roads, the traffic fluctuation of which interlock herewith. (Due to technical difficulties the accident variation survey has not been corrected for the approximately 30% weekdays that are school holidays, but since the variation in principal is found to be identical on schooldays and offdays this cannot be expected to influence the results).

Age variation.

The distribution of age for pedestrians and bicyclists respectively in collision with automobiles in the hospital area from February 1st 1971 - February 1st 1974 appears in figure VI. The distribution corresponds with previous published age distributions, with an age maximum in collisions between walking children and automobiles of 3-8 years and in collisions between children on bicycles and automobiles of 7-14 years. Unfortunately the abrupt fall in number of accidents at the age of 15 (approximately 5 per year) far from compensate, that each year approximately 100 15-year old moped riders are brought to the hospital's casualty room.

Accident situations.

Codified description of the accident situation is available from the police in 128 cases of collision between walking children and automobiles, and in 112 cases of collision between bicycle riding children and automobiles.

The percentage distribution of the walking and the bicycle riding person's accident situation appears in schematised form in figure VII and VIII respectively.

Figure VII shows, that 83% of the walking children are hit during crossing of the road, and of these at least one half during unexpected manoeuvres or when appearing by parked vehicles. Only 1% of the walking children are hit from behind, 4% when playing on the road and 14% in controlled intersections or on the sidewalk.

Figure VIII shows that 65% of the bicyclists are hit in T-intersections and of these, the vast majority during left turn manoeuvres across the road, - about equally frequent in front of following or oncoming traffic, - a manoeuvre which obviously is difficult for the children to perform. Head-on collisions on straight roads have been rare, 4,5%, while 14,3% have taken place in X-crossings and 15,2% have been hit from behind on straight roads, most often in the case where the bicyclist has made a sway towards the road.

Description of the counterpart.

In a previous material the police reports have been examined in regard to evaluation of the adult counterpart's role in collisions between children and automobiles. 109 vehicles had male drivers and 22 women drivers. 118 drivers had owned their license more than one year and 13 less than one year. The material could not be corrected in relevans to age, seniority groups and sex occurence of motorists in the area of traffic concerned, but no immediate excess representation seem to appear.

The speed of the counterpart was estimated less than 50km/h in 18 cases, 50-70 km/h in 16 cases, 70-90 km/h in 3 cases, while no estimation of speed had been set in 106 cases (74%). In the cases of 3 counterparts the blood alcohol was found to be more than 1,5 o/oo, another 2 had a sobriety test carried out while 138 (96%) were judged to be sober and consequently had no sobriety test carried out.

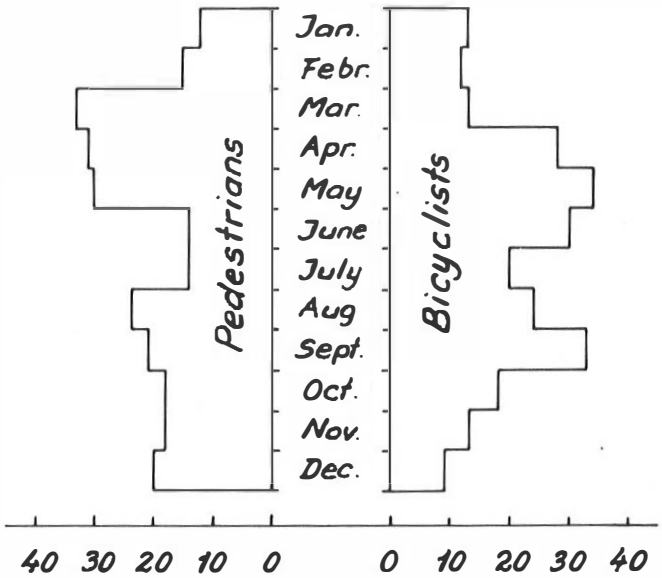
Out of 128 inflicted motorvehicles the police found an indication to have 13 (10%) examined by a driving inspector, who found deficiencies in 5.

Geographical analysis.

During the beginning of the period of investigation a manual plotting of the accidents was done on a city map in the scale 1:10.000. From September 1st 1972 all known places of accidents within Odense City limits, where registered motorvehicles (strong parties) were involved have been characterized by the code of the National Registration Office for the postal address closest to the place of accident. The material has been programmed in such a way, that it is able to give information as to what roads particular types of accidents have occured on, or how many accidents have occured on a certain stretch of road, as well as it is able to transcribe lists of matching case paper numbers for detail analysis.

The material has been taken into practical use by the road- and city planners of the community.

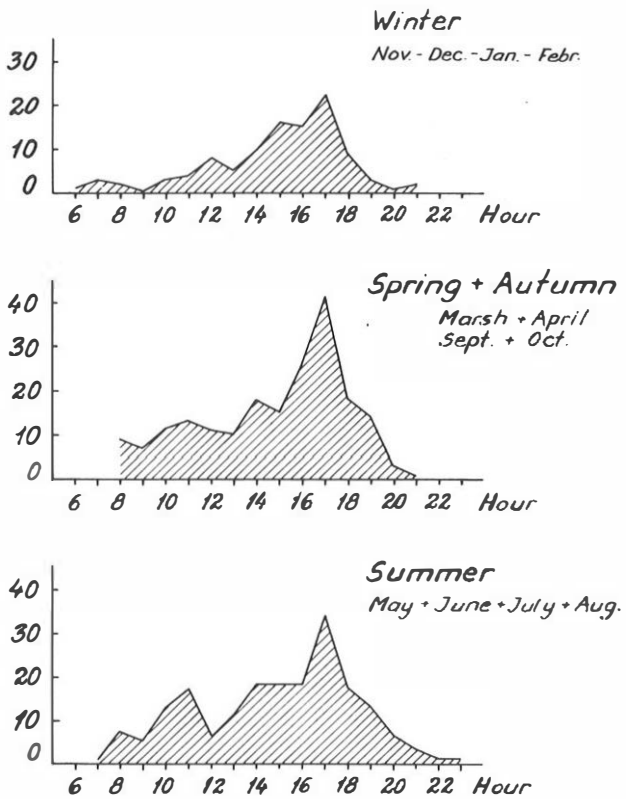
Figure 1.



Children/cars 010271 - 010274.

250 pedestrians 247 cyclists.

Figure 2.



00 - 14 years.
250 pedestrians + 247 cyclists/automobiles.
010271 - 010274.

Figure 3.

Child accidents / Traffic intensity.
Workdays.

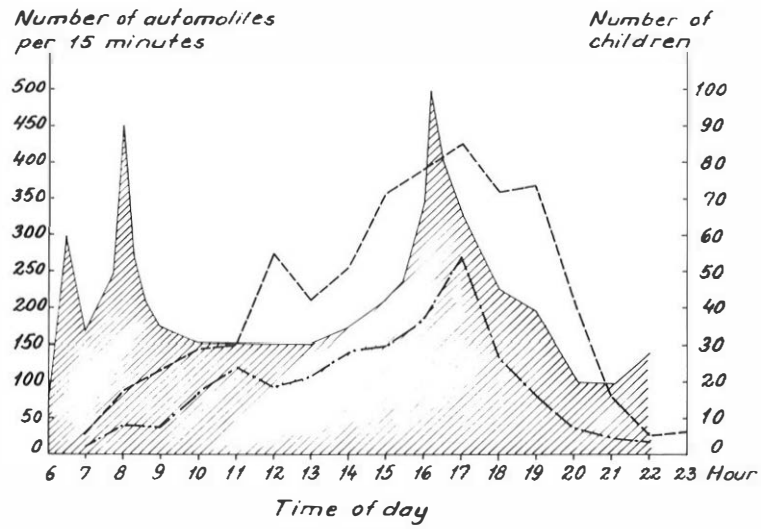


Figure 4.

Child accidents / Traffic intensity.
Saturday + Sonday.

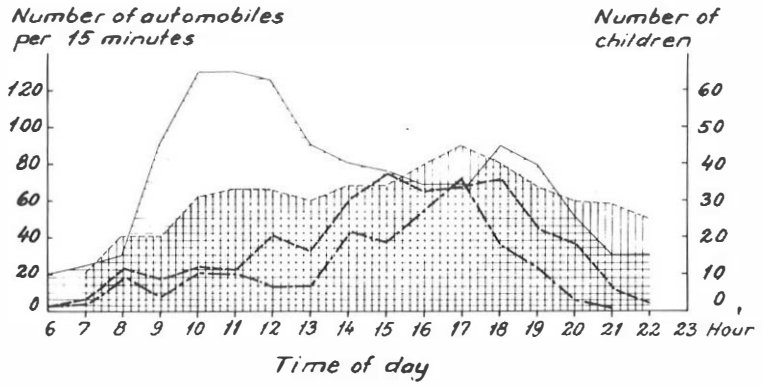
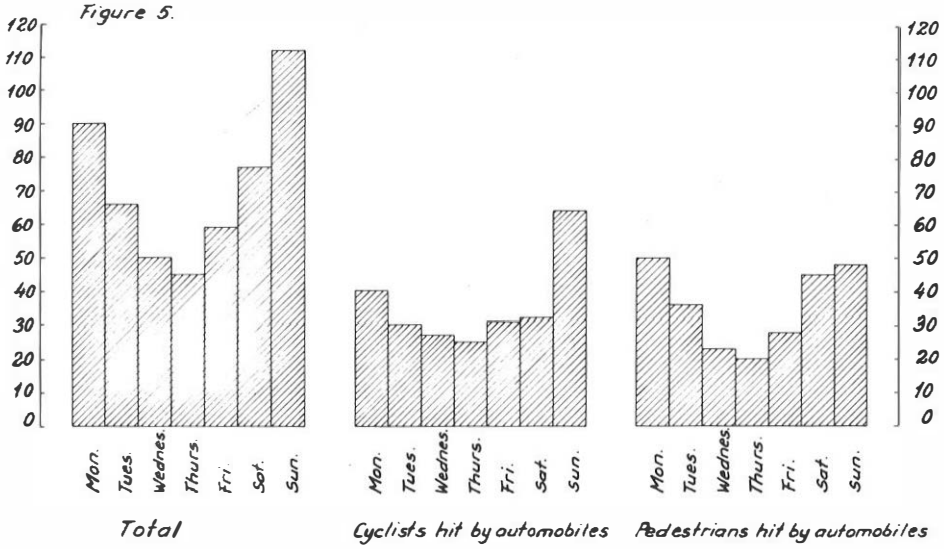


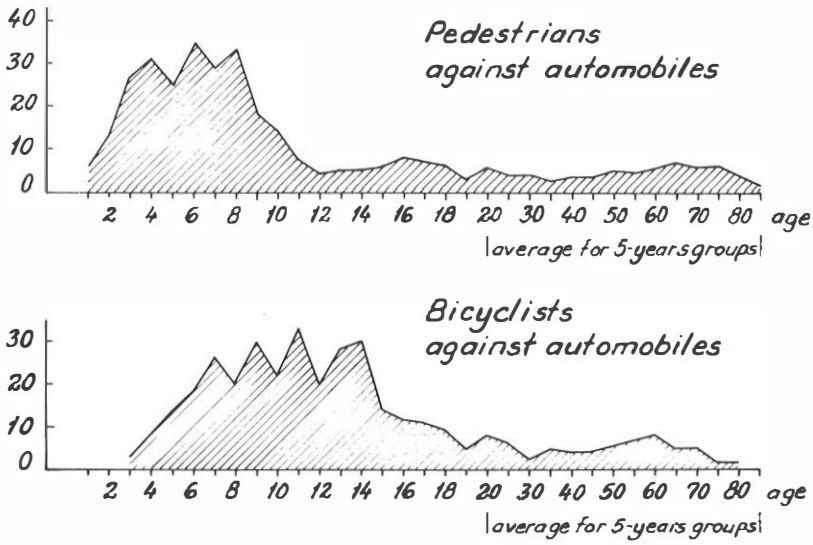
Figure 5.



Weekly distribution of children
00 - 14 years hit by automobiles.
010271 - 010274.

Figure 6.

Number of injured 010271 - 010274.



The age distribution of the material.

Figure 7.

Distribution of accident situations.

10.9

21.9

21.1

42.2

3.1

0.8

100 %

based upon 128 collisions between walking children and automobiles.

Figure 8.

Bicycle riding children 00 - 14 years
Collision accidents.

15.2	Hit from behind on straight road	
4.5	Head on, straight road	
25.0	Side road manoeuvre collision with vehicle going in the same direction	
23.2	Side road manoeuvre collision whith vehicle going in the opposite direction	
14.3	Collision in intersection	
17.9	Coming from sideroad	
100.1 %		

Additional

4 parked automobile
1 opening car door
10 against pedestrian
1 against animal

The effect of restrictions on motoring.

On November the 25th 1973, due to the oil crises, private driving was prohibited on Sundays, along with the imposition of speed limits to 60 km/h in densely built up areas and 80 km/h elsewhere.

From February the 16th 1974 the prohibition was repealed along with the 60 km/h limitation, while the 80 km/h limitation was retained.

On April the 14th 1974 experimental speed limits of 60 km/h was introduced in built-up areas along with 90 km/h outside built-up areas and 110 km/h on high-ways. As a temporary measure these limitations are to last one year.

In the hour of writing the effect of these limitations can be judged for the period of November 25th 1973 to February 29th 1974 (period III) and compared with the corresponding period in the calenders from 1971-72 (I) and 1972-73 (II).

The effect on the children's accidents according to type of conflict grouping appears in table VIII.

Table VIII.

Type of conflict.	Period		
	I	II	III
a) Single, weak	36	35	37
b) Single, strong	7	8	3
c) Weak/weak	1	11	1
d) Weak/strong	38	39	24
e) Strong/weak	0	0	0
f) Strong/strong	11	11	5
Total	93	104	70
Weak only (a+c)	37	46	38
Strong involved (b+d+e+f)	56	58	32

What the fall from 38/39 in the weak/strong type is concerned, and the fall from 56/58 to 32 in all accidents with a strong part is concerned, they are significant when related to the increased risk population (54.700) ($P = 0,01$).

There were 14 Sundays during period III out of which 11 were furnished with prohibition against private driving. On the day-of-week and time-of-year analysis another 5,5 weak/strong accidents were expected on these days, and after the above mentioned correction the remaining fall in accidents is not significant. (An up to date documentation will be presented at the congress).

(Moreover, the analysis shows, that it is necessary to carry out a meaningful graduation of the accidents ahead of the analysis of the effect of further actions, - otherwise the effect of these actions will tend to be veiled by observations which are not susceptible to the action).

Discussion:

Children's single accidents with bicycles seem to be a steady and most likely treatment-refractorary problem. Child-

ren's casualties as automobile passengers occur 4 times as often now as 12 years ago, but in this type of accident, the child is a passive part and the epidemiology cannot be related to the behaviour of the child.

Collisions between children and automobiles occur now twice as often as 12 years ago, and the incidence is still increasing outside a current fall of 35-40% during the newly imposed driving restrictions and speed limits. This type of accident is the most frequent reason for serious and fatal injuries in children and should be given high priority in the lesion- and accident preventive work.

Effective lesion prevention is technologically difficult and hardly economically and politically praticable, and consequently the effort should mainly be oriented towards accident prevention. A rational accident prevention calls for a behaviour- psychological, technological and epidemiological knowledge, which is far from established to the full extent. Epidemiological analysis should primarily be based upon hospital collected materials, which would be more complete and more representative than those collected by the police, but which require supplementary information collected by the police and road authorities in order to be related to traffic describing data.

The area of investigation concerned in the present analysis can be characterized as a mixed suburban and rural area with excess suburban district, in a technologically highly developed country with high living standards and high automobile intensity and with easy and inexpensive access to hospital treatment. The bicycle is the main means of transportation for children already from the age of 4 until the moped age (15 years). The climate of the area is temperate with mild and damp winters with only few slippery road days. Until the last 3 months of the 3-year period of investigation, there has only been a few and then only local speed limits for the motorized traffic. In the kindergartens and the schools of the area, traffic education is given to the children with various intensity. The technological traffic-securing of school roads is sporadic, while most schools have established school patrols who are leading the younger pupil's rush hour traffic in the vicinity of the school.

Apart from relatively more tibial fractures than femoral fractures, the children's lesions did not show any clear difference from those in the adults in the same accident situations, in accordance with the bumper's clearance over the road.

The analysis of the time-of-year, day-of-week and 24-hour variation did not point towards darkness or slippery roads as a quantitative important element. The time-of-year variations certainly reflect the number of out-of-doors children. The day-of-week variation of the collision accidents showed maxima on Saturday-Sunday-Monday, but not excessively many accidents on Monday mornings. The collision accidents showed the same 24-hour variation on workdays as on Saturday-Sundays, and the same variation as the single accidents, always with clear maximum at 5 p.m. Certainly this maximum was more pronounced in collision accidents than in single accidents, and what workday afternoons are concerned, this might be an indication of an increased offer

of collision between the maximum number of out-of-doors children and the heavy rush hour traffic. The lacking reflection of the morning hour's peak traffic in the child accidents might be an expression of a relative good securing of the school road during the morning hours. On Saturdays there is none and on Sundays only doubtful synchronism between adult traffic and child accidents. This seems to show, that the characteristic 24-hour curve of child accidents very much reflects the childrens behaviour more than it reflects the adult traffic. Stina Sandels (7) has investigated variations in preparatory school childrens exposition in traffic areas and demonstrated maxima from 10-11 a.m. and from 3-4 p.m. No analysis is presented from the present area of investigation covering the older children's exposition, but it is presumeably low during the forenoon hours, where they are protected in the schools, and high during the afternoons corresponding with accident maximum. Saturdays and Sundays it is probably more evenly scattered over the day than the accident distribution. Thus it is very likely, that the accident distribution to an extended degree reflect the 24-hour variations in the children's traffic fitness, depending on factors such as tiredness, length of time from last meal, etc. This problem could do with a closer analysis based upon the examination of the children's traffic exposition and a psychotechnical examination of the 24-hour variation in their skills.

The age distribution of the material shows, that steps taken to improve childrens traffic behaviour should start already at the age of 2-3 years for the pedestrians and 3-4 years for the bicycleriders, alternatively attempt to postpone the childrens debut in the traffic. The age maxima are very prolonged for walking as well as for bicycleriding children, which right of does not indicate, that they get used to the traffic, rather that they do not mature to get by as pedestrians until the age of 10-11 and as bicyclists until the age of 14-15. However it cannot be excluded, that the exposition is increasing with age, and consequently they become adapted or a learning takes place.

The analysis of the accident situations shows, that the collision accidents between walking children and automobiles by far take place when the children have to cross the road outside controlled crossings. Going through the police reports it is obvious, that it is a case of impulse action on behalf of the children.

The pattern of collisions between bicycleriding children and automobiles is more varying, but the major part of these accidents took place while the bicyclist was making a left turn, and particularly in T-intersections.

At an examination of the adult counterparts in the collision accidents, it was not possible to demonstrate conspicuous seniority- and age patterns or unexpected sex distribution. The speed, the technical standard of the automobiles and eventual influence of alcohol was incompletely investigated, but in far the most cases the police found these factors not to have been reckless.

By plotting of the accidents on the city map, remarkably

few accidents appeared on the major roads, where the very intense traffic obviously scares the children. The accidents took place mainly on medium size roads and suburban roads, diffusely scattered over the area, only with one actual "black spot", which has been closed for through traffic by now. It is possible, that the continuous analysis will be able to disclose more definate relations between road characteristics and child accidents.

The analysis leaves the impression, that the typical collision between a walking child and an automobile happens on a suburban road, eventually a medium size road, around 5 p.m., and starts with the child crossing the road unexpectedly. The typical bicyclist collisions happen on the same type of road, perhaps with a tendency to shift towards the more trafficed road, on the same time and mostly during unexpected turns to the left. In both cases the accident can be characterized as a collision between an impulsively acting child and a driver who is "normal" in regard to speed, fitness and vehicle.

Thus, to have an effect, the actions taken against the adult road-users should probably be very rigorous, and the effort must mainly be turned towards the childrens behaviour and towards bringing the possibility of collision between the two incompatible parties down, that is separation to the greatest possible extent. It has hardly been completely clarified, how much of a "traffic secure behaviour" it is possible to teach a child. The possibilities are limited by the childs undeveloped psychomotoric skills. "Traffic adaption" of the children is obviously of limited value, in as much as most of the injured children have been exposed to traffic for 2-3 years at the time, when they collide with an automobile.

Therefore, the prevention of child traffic accidents must consist of a running effort towards improvement of the behaviour of the adults and especially of the children in the traffic, along with an effort to separate the parties in time and space. The separation in space ought to be given high priority in the city development. It would hardly be possible to carry this through effectively without legalized consumers demand to the classification of the road system based upon consideration of the weak road-users level of risk.

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Computer analysis by P. Lagoni