## CHILD TRAFFIC ACCIDENTS

## EPIDEMIOLOGICAL AND BIOMECHANICAL ASPECTS.

Johan Wallin, Institute of Forensic Medicine, Odense University, Denmark.

1. Material.
(1) Hospital material.

Since February lst l971, Odense University Hospital has kept extensive records of all persons hospitalized or receiving casualty ward treatment following traffic accidents on public highways. About 3.000 patients are registered annually, but in only $40 \%$ of these cases is a police report made.
The composition of the local population makes this material representative of the whole country.
The traffic accident registration system estimates the severity of injury by a grading system containing 7 severity-groups, representing the predicted incapacity of the patient as follows: $1=$ doubt ful or no incapacity, $2=$ slight incapacity, $3=<2$ weeks, $4=$ 2 weeks to 3 months, $5=3$ to 6 months, $6=>6$ months, 7 = dead. The traffic accident registration system has been described in further detail by E. Nordentoftl).
(2) Follow-up material.

From the hospital material were selected all children aged O-14 years, who as pedestrians or bicyclists suffered a collision with a motor vehicle during 1974. This group totalled 137 children, of which 3 were killed in the accident. It has been possible to follow up 124 of these cases and to interview the child and parents as to the situation leading up to the accident and the details of the accident itself.
The 124 cases consist of 82 boys and 42 girls, 65 bicyclists and 59 pedestrians.
The follow-up examination was made on average ll, 2 months after the accident, and it should be stressed, that the period of incapacity predicted by the hospital was found to be correct in $72,6 \%$ of the cases.
(3) Police material.

This consists of 3 years police reports of collisions between motor vehicles and 0-14 year children. The police reports correspond to the police-recorded fraction (46,2\%) of the 1972-1974 hospital material fulfilling the conditions noted in (2), a total of 143 cases.(Passenger cars only).
2. Epidemiology.
(Hospital material)
Previous investigations have already indicated the distribution of traffic accidents with respect to time of day. But the relationship between accidentdistribution and traffic intensity seems less obvious.
Fig. 1 shows the distribution of traffic accidents with respect to time of day for 0-14 year bicyclists and pedestrians on all days.

It will be seen that the distribution for bicyclists and for pedestrians are more or less identical, and in the following discussion they are therefore treated as a single group.
Fig. 2 shows the time-of-day distribution of traffic accidents for Monday-Friday and Saturday-Sunday respectively. There is a clear difference between these two distributions; particularly obvious is the Monday-Friday maximum at about $17^{08}$ hours.
If fig. 2 is compared with the distribution of traffic intensity with respect to time of day, fig. 3 , it is seen that the sharp difference between Mon.-Fri. and Sat.-Sun. is clearly reflected in corresponding traffic accident distributions. It is striking, however, that the morning traffic is only poorly represented in the accident data, even when schoolchildren are taken as an isolated group (fig. 4). A possible explanation for this phenomenon could for example be that children's traffic abilities follow a diurnal rhythm and thus decline as the day progresses.
The traffic intensity distribution is an average of a number of automatic (24-hour) traffic counts on both a large, fairly heavilyused road (Sanct Jørgensgade) and a less heavily-used residential road (Enebærvej) in 1973. The roads were chosen as typical representatives of the types of roads where children's traffic accidents occur. As can be seen, the distributions are nearly identical, apart from the level of traffic, and they are also known to be virtually constant from year to year.
An analysis has been made in a British paper ${ }^{2}$ ) of the distribution of schoolchildren's traffic accidents with respect to time of day on schooldays and non-schooldays, and significant differences were found. However, no attention was given to the fact that non-schooldays consist of both school holidays and weekends, which may well have different distributions.
In order to investigate this more closely, the traffic accident distribution of $7-14$ year-olds in the present study was divided up into schoolday accidents and school holiday accidents (fig. 4). School holidays make up about $23 \%$ of the days of the year, and in this analysis it was found that $20,9 \%$ of schoolchildren's accidents occurred on school holidays, which indicates that there is no particular concentration of accidents on these days.
The accident-distribution on schooldays is fairly similar to fig. 2 (Mon.-Fri.), following the basic daily variation of traffic intensity. However, the distribution on school holidays differs from the other days. One explanation for this may lie both in a difference in children's traffic exposure and in the fact that traffic intensity on school holidays is highly variable, depending on whether the day is a public holiday (e.g. Easter) or only a school holiday.
In general, however, traffic intensity on school holidays is more like fig. ${ }^{\prime}$ 's Saturday-Sunday distribution than the Monday-Friday distribution.
3. Biomechanical aspects
(Follow-up material
The collision. Fig. 5 shows the point of impact on the vehicle.
$67,3 \%$ of impacts were on the front and $22,7 \%$ on the sides. This material includes all motor vehicles, of which heavy commercial goods vehicles made up lo\%.

Fig. 6 shows the point of impact on the bicycle.
The damage suffered in the collision by the bicycle was also investigated (fig. 7), and assigned to one of six groups graded after decreasing severity of damage. The largest group was group 1 - totally damaged - comprising 22 cases. Under "other damage" were recorded bent handlebars, damaged mudguards and carriers, bent pedals, etc.
Fig. 7 also shows the correlation between the cycle damage severity group and the injury index (average number of injuries per person), and the most frequent serious injuries. The figures show that to a certain extent there appears to be a correlation between the degree of bicycle damage and the bicyclist's injuries.

After the primary collision contact with the motor vehicle (l24 cases) the child was a) thrown away or knocked down (63,7\% of cases) or b) thrown over the bonnet or roof (30,6\% of cases), or c) other or don't know (5,6\% of cases).
If a) and b) are compared (fig. 8) it is seen that both injury index and the most frequent serious injuries were higher in b) than in a). As an explanation, one can note that in situation b) the child comes into greater contact with the dangerous areas around the windscreen than in situation a).

Collision types.
(Police material).
From the literature it appears that the severity of injury (e.g. expressed as AIS) in a frontal collision between an unprotected person and a car depends partly on the shape of the front end of the car (wedge-, pontoon- or box-shaped) and on the speed of impact.
Fig. 9 shows the difference in injuries as related to the shape of the front end and to whether the impact was frontal or from the side. The figure indicates both the total regional damage and serious injury in the various regions, and the severity of injury, calculated as the average of the longest-lasting injury for all persons in the group.

Since the child's height is an important parameter for the collision process it must be emphasized that the distribution in ageclasses was more or less the same within the pedestrian groups and within the bicyclist groups, but different between the two groups (pedestrians vs. bicyclists); the average age for pedestrians was 6,7 years and for bicyclists 10,1 years.

The distribution of speed of impact was found to be roughly uniform in all the groups. It must be emphasized, however, that only in a few cases are the speeds calculated, since in most cases speeds were estimated by the police. This is a weak point in the material.

Fig. 9 indicates that:

1. Collision with pontoon-shapes resulted in a greater frequency and severity of injury than wedge-shapes.
2. Bicyclists suffered a greater severity of injury than pedestrians in all types of collision, this finding is apparently not in agreement with the literature.
3. For both bicyclists and pedestrians, side collisions resulted in greater severity of injury than a frontal collision. For side collisions the point on the car body where contact occurs is presumably very important. The serious cases can thus be the result of contact with the dangerous areas around the front windscreen.
It is also conceivable that the speed of the unprotected party may be of importance, particularly in side collisions. It should be added that in the follow-up study it was found that 23 of 25 children involved in side collisions, but only 5 of 74 children involved in frontal collisions had a considerable speed in the form of running or fast bicycling.
A German report ${ }^{3}$ states that, for pedestrians, side collisions result in a lower severity of injury (NACA) than frontal collisions.
4. The most frequent injury in all cases was commotio cerebri (concussion) and its distribution with regard to severity groups l-7 was more or less uniform in the various collision groups.

The results presented here are to be seen in relation to
(a) that the police material represents the most serious part of the hospital material with regard to frequency and severity of injury;
(b) that hicyclists are heavily represented in the highest severity groups, as shown in fig. 10 (the hospital material);
(c) that the bicyclists on average were 10,1 years old as against the average age of the pedestrians of 6,7 years, and in fig. 11 (hospital material) it may be seen that the 9-11 year-olds have the greatest frequency of injury.

## References:

1) E. Nordentoft, IRCOBI, Proceedings 1973.
2) Transport and Road Research Laboratory: Leaflet 395, 1974.
3) S. Behrens et al., Unfallheilkunde, 79, l09-115, 1976.

Fig. 1 Pedestrians and bicyclists, age $0-14$ / cars period 010271 - 010276


Fig. 2 PEDESTRIANS AND BICYCIISTS, AGE O-I4/CARS

Monday - friday, number $=640 \quad$ Suturday - sunday, number - 146


Fig. 3 TRAFFIC INTENSITY (CARS PR.HOUR)


## Fig. 4

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        PEDESTRIANS AND BICYClISTS. AGE 7-14/CARS
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schooldays. period 010271-010276
monday - friday, number $=379$
saturdoy - sundoy,number $=57$



$P$ : pedestrians, $C=$ bicyclists, $N=110$
Fig. 5 Collision point on motorvenicie
25

26
$N=64$

Fig. 6 Collision point on Bicycle

|  |
| :--- |


|  |  | $\begin{aligned} & \\ & 4 \\ & 4 \\ & 0 \\ & 0 \\ & 0 \\ & 0 \\ & 0 \\ & 5 \\ & 0 \\ & 0 \\ & 0 \\ & 0 \\ & 0 \\ & 0 \\ & \hline \end{aligned}$ | $\begin{aligned} & \stackrel{\rightharpoonup}{b} \\ & \underset{\sim}{E} \\ & \underset{\sim}{4} \\ & 0 \\ & \times \\ & \stackrel{\rightharpoonup}{0} \\ & \underset{\sim}{E} \end{aligned}$ |  |
| :---: | :---: | :---: | :---: | :---: |
| Thrown away or knocked down | 27.0 | 11,5 | 1,50 | 78 |
| Thrown over the bonnet or the roof | 46.0 | 27.0 | 1,73 | 37 |
| Fig. 8 |  |  |  |  |


| Colliston | Frontal |  |  |  | side |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Type | V-shape |  | Pontoon |  | Passenger car |  |
| $\begin{aligned} & P=\text { pedestrions } \\ & C=\text { bicyclists } \\ & \text { Aqe O-14 } \end{aligned}$ | P | c | $p$ | C | P | C |
| Head <br> - Commotio <br> - Fracture of the skull | $\begin{aligned} & 2 \\ & 0 \end{aligned}$ | $\begin{array}{r} 10 \\ 4 \\ 1 \end{array}$ | 50 23 4 | $\begin{array}{r} 50 \\ 31 \\ 21 \end{array}$ | 20 8 3 | 15 8 0 |
| Neck | 0 | 1 | 1 | 0 | 1 | 0 |
| Spinal column | 1 | 0 | 0 | 0 | 0 | 0 |
| Thorax | 0 | 1 | 4 | 2 | 1 | 0 |
| Abdomen | 0 | 0 | 11 | 2 | 0 | 0 |
| Urinary system | 0 | 0 | 1 | 1 | 0 | 0 |
| Pelvis reqion <br> - Fracture | $\begin{aligned} & 1 \\ & 0 \end{aligned}$ | $\begin{aligned} & 1 \\ & 0 \end{aligned}$ | $\begin{aligned} & 9 \\ & 3 \end{aligned}$ | $\begin{aligned} & 3 \\ & 1 \end{aligned}$ | 0 | 1 |
| Arm s <br> - Fracture | $\begin{aligned} & 0 \\ & 0 \end{aligned}$ | $\begin{aligned} & 5 \\ & 1 \end{aligned}$ | 6 | $\begin{aligned} & 9 \\ & 2 \end{aligned}$ | $\begin{aligned} & 6 \\ & 5 \end{aligned}$ | 3 1 |
| Legs <br> - Fracture of femur <br> - Fracture of tibiol | $\begin{aligned} & 8 \\ & 1 \\ & 1 \end{aligned}$ | $\begin{aligned} & 1 \\ & 0 \\ & 0 \end{aligned}$ | $\begin{array}{r} 16 \\ 5 \\ 4 \end{array}$ | $\begin{array}{r} 34 \\ 7 \\ 7 \end{array}$ | $\begin{aligned} & 8 \\ & 1 \end{aligned}$ | $4$ |
| Average of highest severity grade | 3.28 | 3.55 | 3,41 | 3.57 | 3.55 | 3,80 |
| Number of persons | 7 | 9 | 46 | 53 | 18 | 10 |
| Fiq. 9 |  |  |  |  |  |  |


| Grade of severity | 1 | 2 | 3 | 4 | 5 | 6 | 7 | Total number of injuries |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| $\begin{aligned} & \text { Pedestrians } \\ & \mathrm{N}=364 \end{aligned}$ | $\begin{aligned} & 46 \\ & 12,6 \end{aligned}$ | $\begin{gathered} 294 \\ 80,7 \end{gathered}$ | $\begin{aligned} & 161 \\ & 44,2 \end{aligned}$ | $\begin{array}{r} 131 \\ 35,9 \end{array}$ | $\begin{gathered} 19 \\ 5,2 \end{gathered}$ | $\begin{aligned} & 4 \\ & 1,0 \end{aligned}$ | 4,0 | $\begin{aligned} & 659 \\ & 181,0 \% \end{aligned}$ |
| Bicyclists $N=380$ | $\begin{aligned} & 51 \\ & 13,4 \end{aligned}$ | $\begin{gathered} 309 \\ 81,3 \end{gathered}$ | $\begin{aligned} & 130 \\ & 34,2 \end{aligned}$ | $\begin{array}{\|c\|} 126 \\ 33,1 \end{array}$ | $\begin{gathered} 24 \\ 6,3 \end{gathered}$ | 12 3,1 | 16 4.2 | $\begin{aligned} & 668 \\ & 175,7 \% \end{aligned}$ |

Fig. 10 Children $0-14 /$ cars

| Age groups | 0-2 |  | $3-5$ |  | 6-8 |  | 9-11 |  | 12-14 |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| $\left\lvert\, \begin{aligned} & \mathrm{P}=\text { pedestrians } \\ & C=\text { bicyclists } \end{aligned}\right.$ | P | C | P | C | P | C | P | C | P | C |
| Injuries | 48 | 2 | 211 | 58 | 250 | 174 | 108 | 238 | 49 | 207 |
| Persons | 28 | 2 | 118 | 36 | 138 | 102 | 56 | 127 | 28 | 120 |
| Index of injury | 1.71 | 1.00 | 1.79 | 1.61 | 1.81 | 1.71 | 1.93 | 1.87 | 1.75 | 1.73 |

