

ROAD ACCIDENTS EPIDEMIOLOGY AND CONSEQUENCES
OF HEAD TRAUMA FOR CHILDREN

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ABSTRACT

Road accidents represent an important risk for children, would they be pedestrians, cyclists or car passengers. In France, 646 children under 15 years old have been killed in 1984. In order to specify the real distribution of risks, the circumstances and the lesional consequences of accidents, an epidemiological investigation has been set up at Marseille Nord Hospital in the pediatric surgery department.

The analysis of the sample gathered during more than 2 $\frac{1}{2}$ years shows the high frequency of head injuries : child car passengers suffered the most serious ones. At the second rank for frequency and severity were the injuries to lower and upper limbs suffered by child pedestrians and two-wheelers. The insight to severe head injuries confirms the greater propensity of children for recovering from skull and brain lesions than adults.

INTRODUCTION

In an industrialised country as France, children deaths are attributable to accidental causes in nearly 20% of cases. Among the various accident situations, road traffic accidents account for 50% of fatalities for children aged 5 to 14 years, that represents approximately twice the percentage of adults. In France, national statistics indicate that road traffic accidents severity is quite comparable for children between the three users' categories - pedestrian, cyclist, automobile passenger. But in each category, the risks depend on child's age. These are observations quite distinctive from the adults' situation.

Without omitting the researches undertaken for improving road equipment and signalling as well as for road safety education, it is important to carry on the researches on secondary safety. In that aim, an epidemiological study of road accidents has been set up in order to better analyse the risks for children depending on their situation in traffic and to describe the most important lesional factors.

This paper will present the main results gathered in the survey made at Marseille Nord Hospital. Then head trauma cases will be detailed with special emphasis on possible sequelae.

1. PRESENTATION OF THE SURVEY'S SAMPLE

The settlement of a specific survey of children accidents is necessary to gather reliable information on accident circumstances and medical findings. Children under 15 years account for only one fourth of the population, which necessitates to undertake a data collection more widespread than that of bidisciplinary surveys. Two imperative points were fixed for this specific survey :

- sources at hospitals in pediatric departments with emergency rooms : this should enable to gather all types of accidents and all injury severities
- collection of detailed information on accident circumstances and on the child's situation at the time of accident in complement of injury description.

The interest of a good collaboration with the pediatric surgeons comes from the opportunity of collecting fuller information from the interview of the child and/or his parents or accompanying persons in particular in case of hospitalization. This has been undertaken since April 1982 at Marseille Nord hospital with a quite satisfactory follow-up.

The enquiry form contains one sheet on which the accident circumstances and the child characteristics are gathered. The second sheet describes the child's injuries. The analysis of the medical evaluation will be reduced as compared to the bidisciplinary investigations by the fact that only one lesion will be coded for each body segment : skull, face, eyes, neck, dorso-lumbar column, upper limbs, osseous thorax, thoracic viscera, abdomen, pelvis, lower limbs. Head trauma and unconsciousness will be separately coded. The AIS 1980 scale (abbreviated injury scale) is used to indicate the lesions' gravity.

It is asked to the medical staff to fulfil one form for each injured child who is admitted to the emergency room, would the child come back home after the cares or remain hospitalized. The data collection gave from April 1982 to September 1984 a sample of 328 road accident cases in which children aged 0 to 15 years were involved.

I.1. Road users' categories : in comparison to the distribution observed in France (1979 data source), our sample contains a greater percentage of pedestrians (Fig. 1). This difference can be explained by the geographical position of the hospital - suburb with a high population density.

I.2. Accident location : for the same reasons, the accident location is not representative, with a huge prevalence of injured children in urban accidents (Fig. 2). However it can be noticed that, among automobile child passengers, 14% were travelling on highways, and 13% on main roads.

I.3. Age distribution : the distribution by age group depends on the road user's category. It is quite consistent to observe that the pedestrian children aged 5 to 9 years incur a higher risk as they are turbulent and curious, that children on two-wheel machines are more exposed when they are 10 to 14 years old as they move about alone (Fig. 3).

The cases of 22 children aged 15 years have been included in our sample though they exceed the usual age limit. But their number and involvement on light motorbikes (under 80 cm³) constitute an interesting unit.

As concerns car occupant children, they are well distributed in the three age groups.

I.4. Sex distribution : as it is widely observed, boys are more frequently involved in accidents than girls (195 and 131 respectively in our sample). The lack of balance is particularly marked in the two-wheeler category, the boy being more impetuous. And it is normal to get an equal distribution for car passenger children, corresponding to the sex distribution in the population (Fig. 4).

I.5. Overall severity : the presence of 6 uninjured children is explained by the fact that they were involved in the same accident as another child which was brought to hospital. The overall injury severity is illustrated by the MAIS (maximum AIS) on figure 5 . Most of the cases are lightly injured children (MAIS 1) in each road users' category : 67% of the sample. Children with middle gravity injuries (MAIS 2) represent 16% of the sample. They are relatively more numerous in the two-wheeler's category. The seriously and fatally injured children $MAIS \geq 3$ represent 15% of the sample. It is worth noting that no case was recorded with MAIS 4 or 5, that 5 car passengers and 2 pedestrians were killed.

II. ANALYSIS OF THE LESIONAL TYPOLOGY

Here is presented the analysis of the lesional typology for each road users' category and head trauma will be more thoroughly studied in the next chapter.

II.1. Pedestrian accident cases : among the sub-sample of 154 child pedestrians, 2 fatalities must be deplored. A 7 years old child died 3 days after he was impacted by a car near the school exit. He suffered from a major head trauma. The other child is a 10 years old girl who died 27 days after having been swept by a car on the side walk of a main road. She suffered from many fractures and a major head trauma.

Serious injuries sustained by the other children were :

- head trauma with long unconsciousness (< 24 h) : 4 cases AIS 5
- complicated lower limb fracture : 1 case AIS 4
- skull fracture : 2 cases AIS 3
- upper limb fracture : 1 case AIS 3
- pelvis fracture : 1 case AIS 3
- lower limb fracture : 20 cases AIS 3

Injuries affecting neck, face, dorso-lumbar column, thorax were light and very rarely coded AIS 2. No trauma to thoracic and abdominal viscera was reported. 50 head trauma (AIS 1) and 14 losses of consciousness (AIS 2) complete this picture.

An evaluation of these accident severities can be highlighted by the number of $AIS \geq 3$ lesions referred to the sample figure. So for child pedestrians, 29 serious lesions are listed, i.e. 0.188 SL/child.

II.2. Two-wheelers accident cases : Aside two children who were passengers on motorcycles ($\geq 80 \text{ cm}^3$), the sample of 79 children is distributed on 29 bicycles and 50 motorbikes ($< 80 \text{ cm}^3$). The overall gravity MAIS does not differ according to the machine (Fig. 6).

None of the 81 involved children died. The serious lesions were :

- loss of consciousness ($< 24 \text{ h}$) : 1 case AIS 4
- abdomen - intestine perforation : 1 case AIS 4
- upper limb fracture : 5 cases AIS 3
- lower limb fracture : 7 cases AIS 3
- pelvis fracture : 1 case AIS 3

Lesions to the neck, face, vertebral column and thorax were light and no thoracic viscera injury was registered.

This picture is completed by 14 head trauma (AIS 1) and 8 losses of consciousness (AIS 2). The influence of helmet wearing will be discussed further.

So the two-wheelers children suffered from 15 serious lesions (AIS ≥ 3), i.e 0.185 SL/child.

II.3. Automobile passengers cases : 93 children were travelling in a passenger car. 23 children were front passengers, 7 of them were under 10 years, although they were required by law to seat at the rear. 15 of them were not restrained by the three point belt or were on adult's lap (Fig. 7).

67 children were rear passengers. Only 7, aged from 0 to 4 years, were restrained in a safety child device : their location on the rear bench was not detailed. As shown on figure 8, it appears that the front seat is much more dangerous for the child than the rear seat. But our sample is not large enough to conclude on the influence of the restraint systems, particularly in the front seat. This is to be related to the low usage rate observed during transportation of children in cars (DEJEANNES - 1).

5 deaths were deplored, 4 of them affected young children under 4 years. Two infants (2 and 10 months), held on an adult's lap at the front died from severe head trauma (unconsciousness and skull fracture) ; one of them sustained a post traumatic meningitis. Another 1 month old infant, held on her mother's lap at the rear died after a severe head impact against the B pillar during a lateral crash. A 4 years old boy died immediately after his ejection through the side door - he sustained a cervical fracture and a deep crush of the skull. The last fatality is the case of a 11 years old girl who was seated at the front and restrained by a three point belt. The cervical fracture and the bruises observed on her body led to attribute these lesions to the restraint system.

The other serious lesions were :

- lower limb fracture : 4 cases AIS 3
- upper limb fracture : 1 case AIS 3

This picture must be completed by 35 head trauma (AIS 1) and 11 losses of consciousness (AIS 2).

So the passenger car children sustained 11 serious lesions (AIS ≥ 3); i.e 0.118 SL/child.

It is worthwhile pointing out two phenomenons specific to automobile crash situations :

- Ejection out of the car : it has been reported for 16 children (17% of the sample), which is a high figure. They were all seated at the rear. As shown on this table, the injury severity is relatively higher for the ejected children group :

MAIS	0	1	2	3	4	5	6
Ejected	1	10	2	3	0	0	1
Non ejected	3	57	10	3	0	0	4

It must be added that 9 out of the 35 head traumas and 4 out of the 11 losses of consciousness (AIS 2) concerned ejected children.

- Projection against the windshield : it was reported for 5 children seated at the front. 4 of them suffered from face lacerations. They were 2, 7, 12 and 14 years old. The other child, 13 years old, sustained a skull contusion. At last, one child aged 3 years, seated on the center rear seat, was thrown ahead during a sudden braking and suffered from face bruises.

II.4. Discussion

The survey points out some important information with respect to the typology of lesions sustained by children involved in road accidents.

The sample includes a large ratio of light lesions (68%) quite evenly distributed between the 3 users' categories. As for serious injuries differences are more noticeable : on the one hand they affect the cephalic area and on the other hand the limbs. This is in accordance with other surveys (BOURRET-2, NORDENTOFT-3, ROMIEU-4).

But their frequency and severity depend on the users' category. In particular we notice :

- .Two-wheelers suffer from numerous lesions to upper and lower limbs but their head injuries are generally not severe,
- .Car passenger children sustain severe and even fatal head lesions more frequently,
- .Pedestrians sustain lesions to lower limbs and to the head as well.

This lesional pattern differs from the adults' one on another finding. Indeed, no thoracic internal or osseous lesion is reported and only one abdominal injury has been observed (AIS \geq 2). Even though in our sample, post-mortem examinations were not always available and these lesions could have been suffered by the affected children, the same tendency has been expressed by LOWNE (5), and WALZ (6) for car passengers at least. Identically severe injuries to the neck affected children ejected from the vehicle, which had been noted on the larger sample of the bidisciplinary accident investigations (DEJEAMMES-7).

III. ANALYSIS ON HEAD INJURIES

As precedingly, head injuries will be analysed for each road users category, presentation which is all the more justified as these injuries are produced by mechanisms peculiar to each traffic mode.

In our sample, head injuries are mainly those encountered at the skull and brain. Indeed, face lesions are only mild (AIS 1) - abrasions and soft tissues wounds - except one case of lower mandible fracture sustained by a two-wheeler child.

Head injuries are referenced as head trauma (AIS 1), loss of consciousness (AIS 2 to 5) and skull fracture (AIS 2 to 6). So figure 9 gives the distribution of head injuries depending on road users' categories. It can be noted at first that head traumas (AIS 1) are twice less frequent among two-wheelers (17%) than among pedestrians and car passengers (32 and 38%). On the other hand, severe lesions (AIS \geq 2) are relatively more numerous among car passengers (19%).

The cases of severe head injuries (AIS \geq 3) have been taken from the sample and the follow-up of these patients has been requested of the medical staff who were able to precise their recovery from the latest out-patients advices.

III.1. Pedestrian cases : 19 children suffered from 22 moderate to severe lesions (AIS \geq 2).

- . 5 children were impacted by a two-wheel machine and sustained :
 - a loss of consciousness (<15 mn) AIS 2 : 4 cases
 - a loss of consciousness AIS 2 and a skull fracture AIS 3 : 1 case.This 4 years old child recovered without sequelae.

None of these children received any significant injury to another body part than the head.

- . 14 children were impacted by a car and sustained :
 - a loss of consciousness (<15 mn) AIS 2 : 3 cases
 - a loss of consciousness AIS 2 and a fracture of :
 - upper limbs : 1 case
 - clavicle : 3 cases
 - lower limbs : 2 cases.

These losses of consciousness got simple followings.

- a loss of consciousness $>$ 24 h, AIS 5 : 5 cases as following :
 - a 11 years old boy stayed for 16 days at the reanimation room (coma 3). He went out suffering from a hemiplegia of his right arm and psychologic disturbances (irritability),
 - a 7 years old boy died 3 days after accident without regaining consciousness (coma 3). He suffered a parieto-occipital skull fracture,
 - a 10 years old girl died 27 days after accident without regaining consciousness (coma 3). She suffered multiple fractures to the limbs and pelvis,
 - a 13 years old girl with a sagittal skull fracture was treated at the reanimation room for 15 days. The following was not indicated,
 - a 8 years old boy after a coma 2 suffered from a phrenic paralysis and a monoplegia of his left upper limb. His left femur fracture was well reduced.

So two fatalities and two cases of sequelae with slow recover were registered.

III.2. Two-wheelers' cases : 9 children sustained 10 head injuries of AIS \geq 2 gravity.

- . 6 children were riding a bicycle and sustained :

- a loss of consciousness (< 15 mn) AIS 2 : 4 cases
- a loss of consciousness (< 15 mn), a fracture of the upper limb and a perforation of the small intestine : 1 case. This 12 years old child hit by a car, recovered without sequelae after 12 days at hospital.
- a loss of consciousness (< 24 h) AIS 4 : 1 case. This 13 years old boy fell alone on the ground and recovered without sequelae.

. 3 children were riding a motorbike (< 80 km³) and sustained :

- a loss of consciousness AIS 2 : 1 case
- a loss of consciousness AIS 2 and a mandible fracture : 1 case
- a loss of consciousness AIS 2 and a skull fracture : 1 case.

This 14 years old boy, impacted by a car, was wearing a helmet. He was hospitalised for 8 days and recovered without sequelae.

So, severe head lesions uncountered by two-wheelers in our sample got simple followings, even though their frequency was quite comparable to that of pedestrians.

It is interesting to examine the influence of the helmet for motorcyclists. It must be recalled that in France the helmet usage is required by law to every motorcyclist on every circumstances. The enquiry gives information about the helmet for 49 among the 52 children involved on a motorcycle. The following table indicates the quality of helmet wearing and the corresponding head injuries :

Helmet	no	fastened	non fastened
N	19	23	7
Head trauma			
Face, AIS 1	11	7	4
Skull-brain AIS ≥ 2	2	3	0

One must be cautious however, as far as informations gathered on the forms were given by the injured child, a witness or a policeman but could not be controled.

It appears that, when it is fastened, the helmet avoids mild injuries to the head. However this sample is too small and the quality of helmet wearing should be confirmed in order to conclude about helmet efficiency in preventing more serious injuries.

III.3. Car passengers' cases : 16 children sustained 18 lesions AIS ≥ 2. 4 of them were right front passengers : one child was restrained by a three point belt. Only one of the rear child passengers was restrained in a special device.

Injuries and their consequences are the followings :

- a loss of consciousness (< 15 mn) AIS 2 : 6 cases. The followings were simple. One of the children had been ejected. Children were 7 to 14 years old.
- skull fracture (AIS 2) : 2 cases. The children aged 14 months and 9 years were hospitalised for 4 days and recovered normally.

- a loss of consciousness AIS 2 and a skull fracture : 1 case. This 10 years old child had been ejected. After 5 days at the hospital, he came out without sequelae.

- a loss of consciousness AIS 2 and a femoral fracture : 2 cases. The children, 10 months and 13 years old, had been ejected and recovered normally.

- a loss of consciousness (< 24 h) AIS 4. One infant, 2 months old, was on the adult's lap at front, the other infant, 1 month old, was hold on the adult's lap rear and hit the B pillar of the car. They both died less than 3 hours after accident.

- a loss of consciousness AIS 2 and a cervical fracture (C₂). The 11 years old girl (1m 45, 48 kg) was restrained by a three point belt at front. The belt is likely to have produced the neck injury which was fatal.

- a skull fracture with great damage and a cervical fracture (C₃) involving immediate death. The 4 years old boy had been ejected through the side door after a lateral impact.

- a skull fracture (AIS 2) with death following upon a postrauma meningitis. The 10 months infant was hold on the adult's lap at front.

So it can be noted that head injuries got extreme consequences, either simple followings or fatal consequences for 3 infants. Differing from pedestrians cases, no case of long coma, with sequelae or not, was registered among child car passengers.

III.4. DISCUSSION

Several authors have emphasized on the absence of correlation between skull fractures and intracranial damage, for adults or for children (SELLEY-8, HENDRICK-9). Our sample is quite small but it tends to indicate that the presence of skull fractures and losses of consciousness, isolated or associated, depends on road users categories as shown on this table :

	<u>skull fract.</u>	<u>L.C.</u>	<u>L.C + fract.</u>
Pedestrian	0	16	3
2-wheeler	0	8	1
Car pass.	3	11	2

Isolated skull fractures concerned child car passengers. They had simple followings for two children whereas a post-trauma meningitis became fatal for one infant.

Moreover, in case of associated skull fractures and losses of consciousness, the findings recorded on medical files tend to indicate that no correlation can be made between fracture extent and neurological disturbances. CRAFT (10) went to the same statement.

It is possible to precise some tendencies for the more serious injuries consequences, except in the case of fatalities caused by lesions to other part than the head :

- children deaths after a brain injury were almost immediate for infants or followed a long coma phase for older children,

- cases of neurological sequelae with slow recover concerned pedestrian children of middle age.

CONCLUSION

This epidemiological survey on traffic accidents involving children leads to valuable informations though some limitations of the data collection procedure must be recognised :

- the term "epidemiology" is somehow usurped. Indeed the forms cannot be filled absolutely systematically by the medical staff who is hustled by emergencies at some times,

- because of the sources at hospital, some details on the vehicle and circumstances are missing to precise some injury mechanisms,

- the geographical position of Marseille hospital concentrates certain road users categories and types of accidents.

In order to diminish these drawbacks, the data collection is continued in another hospital but its sample is still too small to be validly investigated and added to the present one.

Despite this reservation, our analysis confirms the results of investigations made in other countries and in France. The general injury typology is characterised by a high frequency to the head, child car passengers suffering the most serious head injuries. Lesions to upper and lower limbs were frequent for child pedestrians and two-wheelers. It must be recognised that serious lesions to the limbs were fractures which consolidate very well and no ligament lesion was observed. Futhermore, lesions to thoracic and abdominal viscera were very rare. Injuries to the cervical rachis, if very rare, were unfortunately lethal.

The detailed analysis of head injuries enhances the differences between road users categories. In particular, child two-wheelers presented less severe injuries. It would be interesting to verify from a wider sample if helmet usage is correlated to this result.

Child pedestrians presented less severe head injuries than child car passengers and less frequent injuries than adult pedestrians.

These results confirm the medical statement, i.e that children can recover more rapidly and with less sequelae from skull and brain injuries than adults. However our efforts should be continued to describe the lesional mechanisms and to study thoroughly neurological examinations of serious head traumas in order to work on countermeasures.

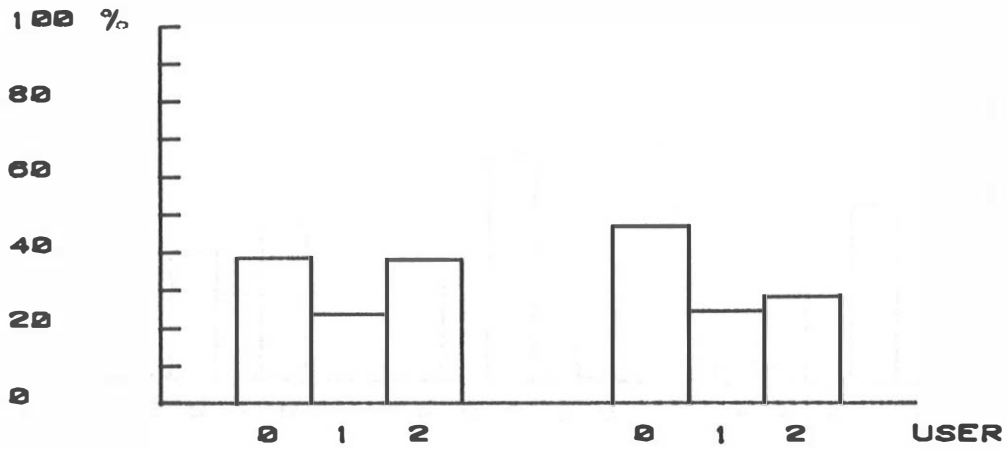
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**Fig.1 CHILD SURVEY MARSEILLE
USERS CATEGORIES**

0: PED
1: 2-W
2: CAR



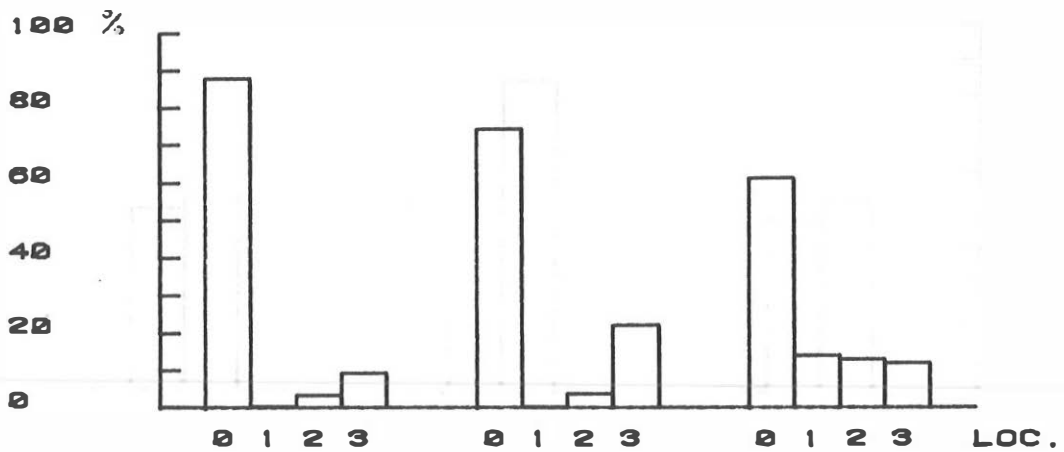
F
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MAR
328

LOC.
N

**Fig.2 CHILD SURVEY MARSEILLE
LOCATION AND USERS**

0: URBAN
1: HIGHWAY
2: ROAD
3: OTHER



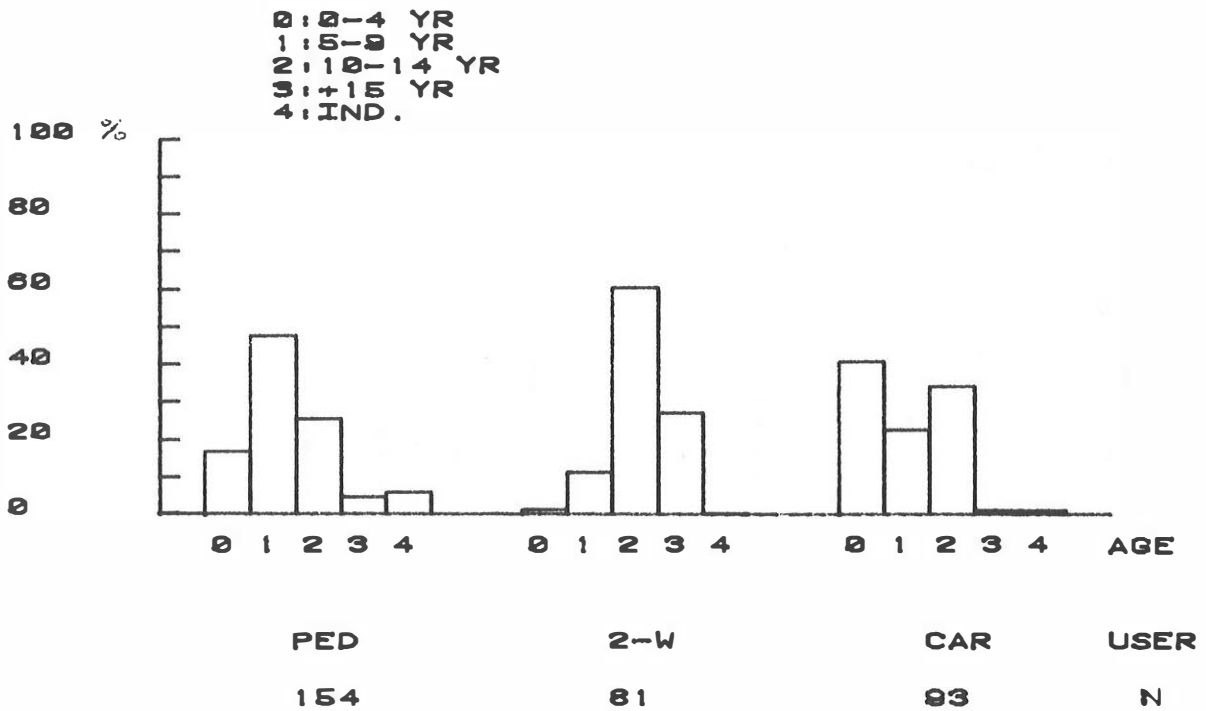
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2-W
81

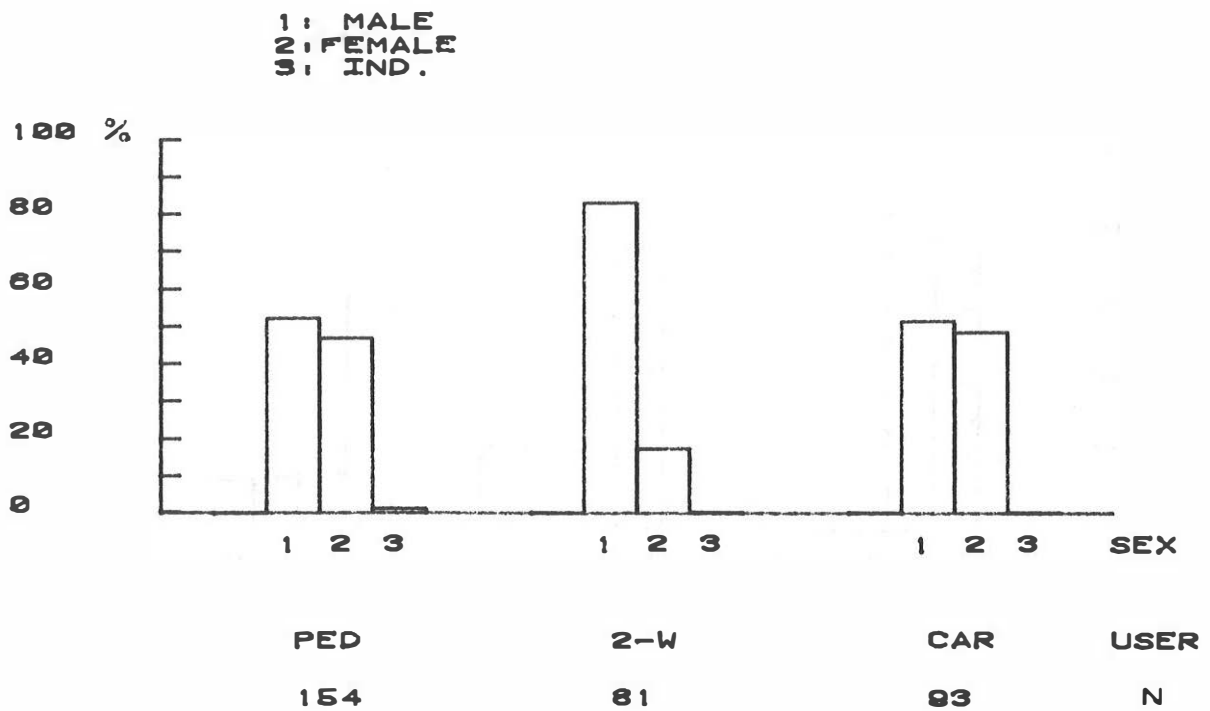
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USER
N

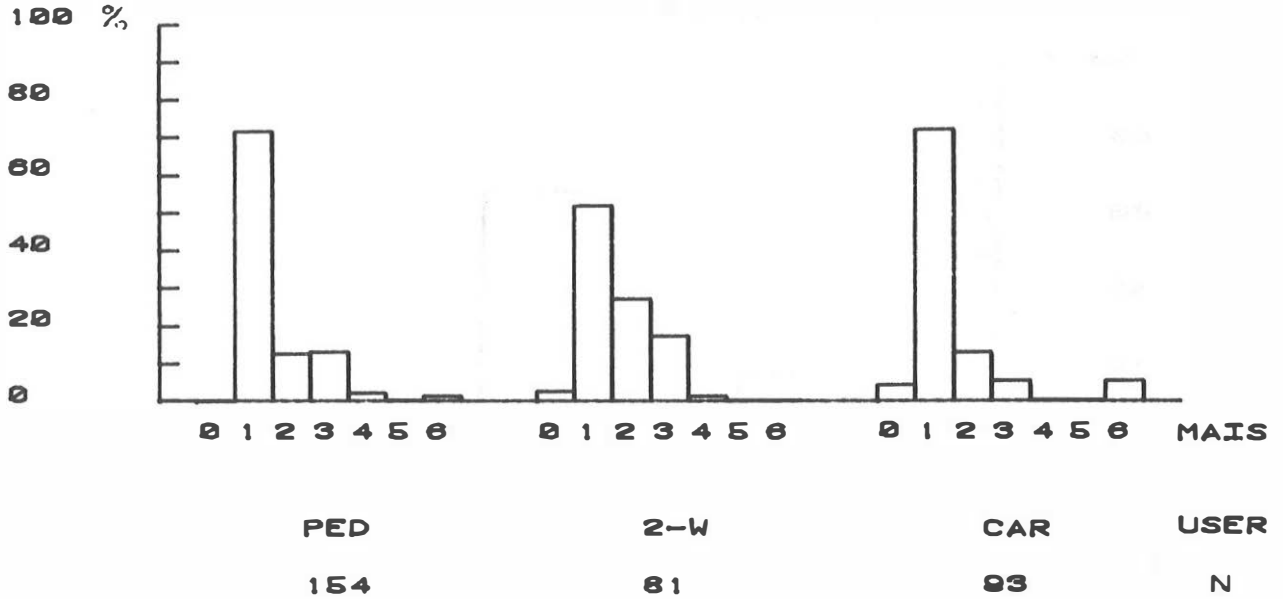
**Fig.3 CHILD SURVEY MARSEILLE
AGE AND USERS**



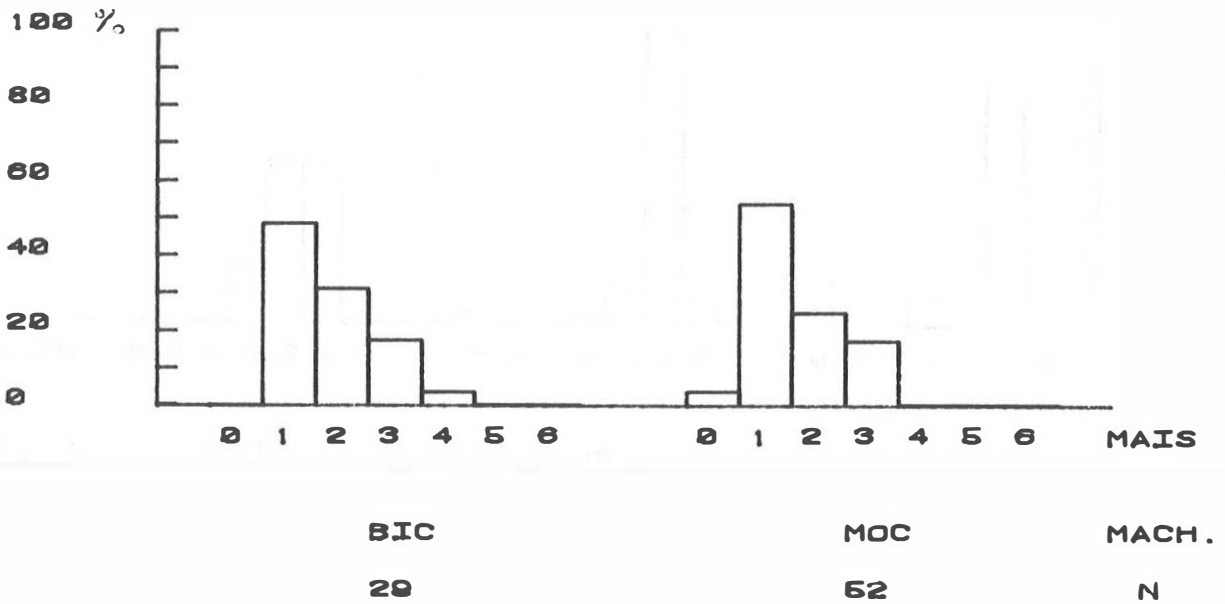
**Fig.4 CHILD SURVEY MARSEILLE
SEX AND USERS**



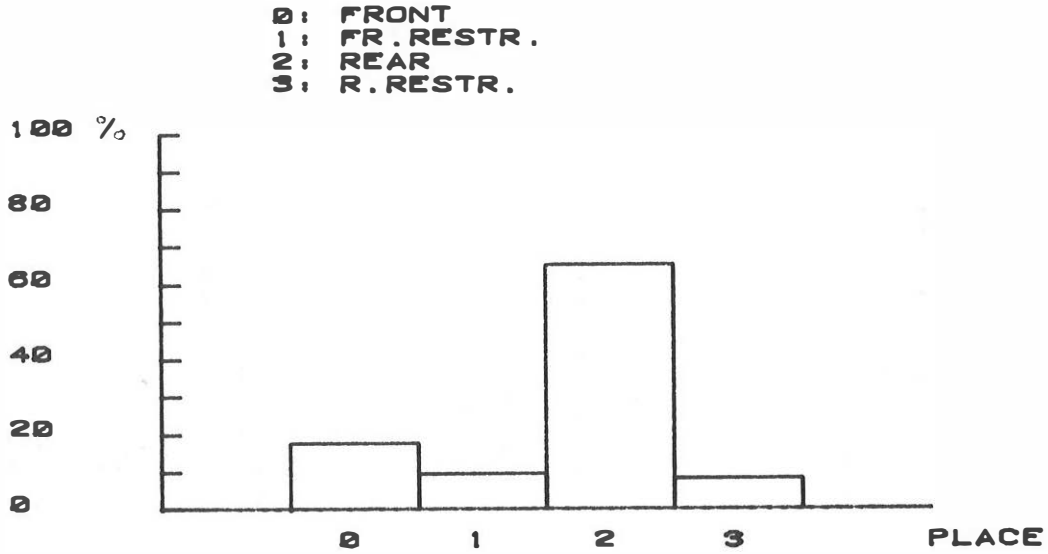
**Fig.5 CHILD SURVEY MARSEILLE
MAIS AND USERS**



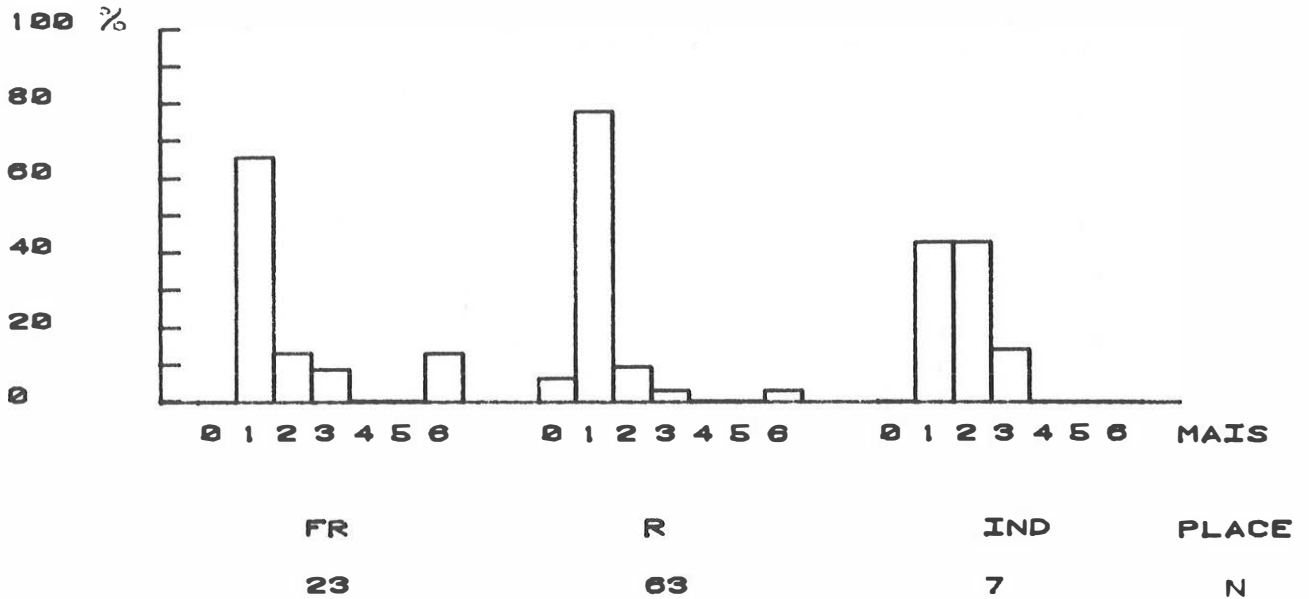
**Fig.6 CHILD SURVEY MARSEILLE
MAIS AND 2-WHEEL MACHINES**



**Fig.7 CHILD SURVEY MARSEILLE
PLACE AND RESTRAINT IN CAR**



**Fig.8 CHILD SURVEY MARSEILLE
MAIS AND PLACE IN CAR**



**Fig.9 CHILD SURVEY MARSEILLE
HEAD LESIONS AND USERS**

**0: NO
1: HEAD TR. 1
2: UNCONS. >=2
3: SKULL >=2**

