EPIDEMIOLOGY OF BICYCLIST'S INJURIES

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INTRODUCTION

In 1989 3.090 persons were treated at the Odense University Hospital for injuries sustained in road traffic accidents. 2.097 were injured bicyclists. The over all incidence of injuries following road traffic accidents in the municipality of Odense (1989) was 15.2 injured per 1000 inhabitants. The incidence of injured bicyclists were 9.2 per 1000. Traffic census carried out by the municipality has shown that the overall traffic intensity has been constant over the past ten years in the city of Odense. The number of injured bicyclists increased during the years 1979-1981. There is no data available from 1981 to 1990. The result of the 1991 traffic census is not yet known.

Figure 1. The distribution of injured in road traffic accidents treated at the casualty room, Odense University Hospital in a ten year period (1980-1989) according to the type of transportation.

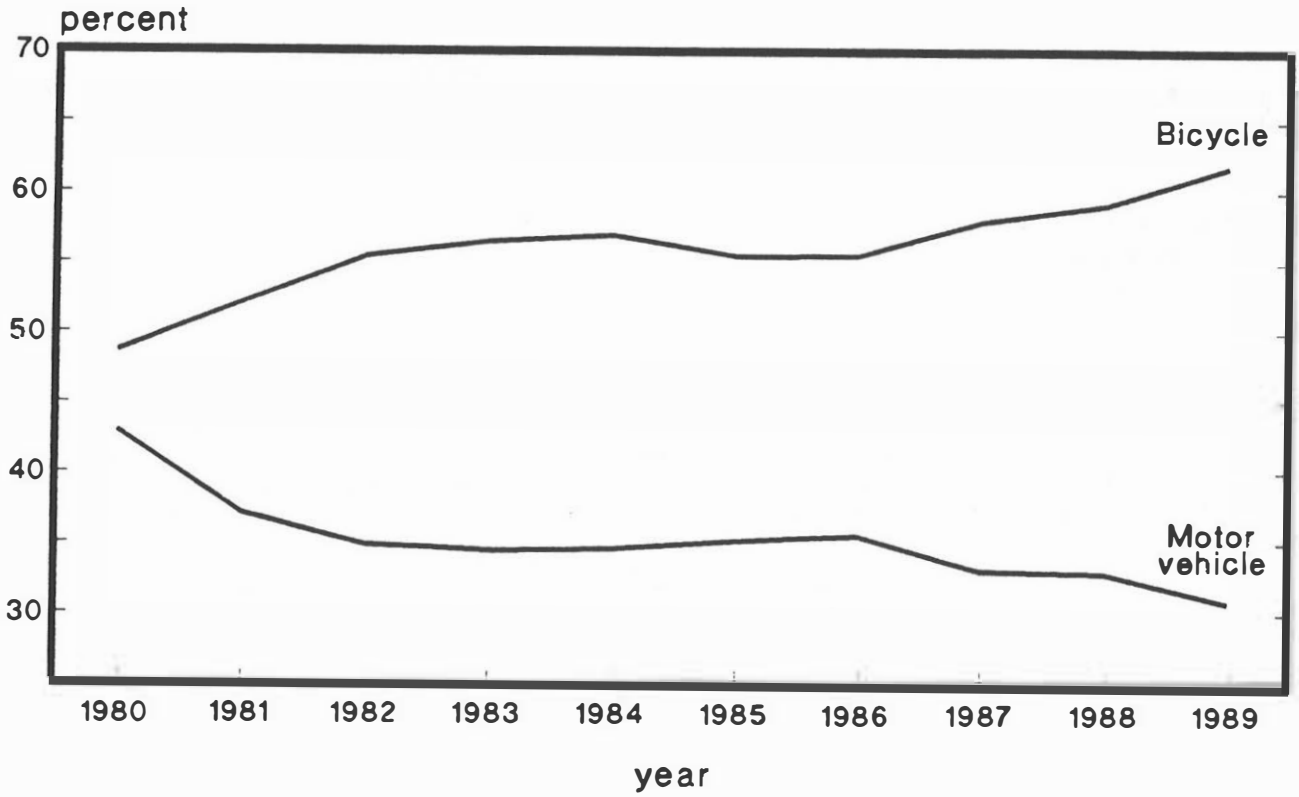


Table 1. **The distribution (percent) of bicyclists injured in road traffic accidents treated at the casualty room, Odense University Hospital in a ten year period (1980-1989) according to the type of accident.**

Type of bicyclists' accidents	Year									
	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
Single accidents	1088	1074	1205	1187	1300	1231	1255	1228	1341	1476
Accidents with a counterpart	375	455	547	558	475	522	561	549	569	621

OBJECTIVES

The aim of this study has been to reveal possible patterns, i.e. clustering, in road traffic accident circumstances in order to establish a basis for accident prevention programmes.

METHOD OF RESEARCH

All injured bicyclists from a one-year period (09.01.1989 - 08.31.1990) have been identified from the Accident Statistics Register. Information was then obtained from three sources:

	Hospital based accident register	Questionnaire	Police records
Name, age, sex	x		
Accident information	x	x	x
Injury information	x		
Police reported			x

The Accident Analysis Group collects detailed information on all patients treated at the casualty room at the Odense University Hospital including: name, age and sex of the injured; time and place of the accident; mode of transport and possible counterpart; use of protective measures; treatment; ICD-classification of injuries; injury location severity according to AIS, and place of final treatment.

An extensive questionnaire with 48 questions was distributed to all the injured bicyclists. 82.9% returned the questionnaire (3.9% did not fill in the questionnaire), 2.6% could not be located (address unknown), 0.9% had died, and 9.8% did not respond.

The police are obliged to report accidents to the Central Bureau of Statistics. However, injuries which

are thought to be minor do not necessarily have to be reported in Denmark. As a result of this rule, under-reporting of certain types of accidents is a well-known phenomenon. The police figures are stored on computer in the Central Bureau of Statistics. The A & E data are stored at the Funen County computer central which receives a copy of the police figures and combine them with the A & E data by means of the unique person number and date of the accident. 1989 data were used for this part of the investigation.

Odense University Hospital serves as accident and emergency hospital for a population of 240.000. For epidemiological calculations only inhabitants of the Odense Municipality were included, as this area is well defined. The age- and sex specific incidences were calculated on the basis of the population census January 1,1990.

RESULTS

Amongst the 1731 injured bicyclists in the one year sample (Group 1) 980 (57%) were men and 751 (43%) female. The age distributions for the male and female casualties are shown in Figure 2. The age- and sex-specific incidences are given in Table 2.

Figure 2. Age and sex distributions for the 1731 injured bicyclists.

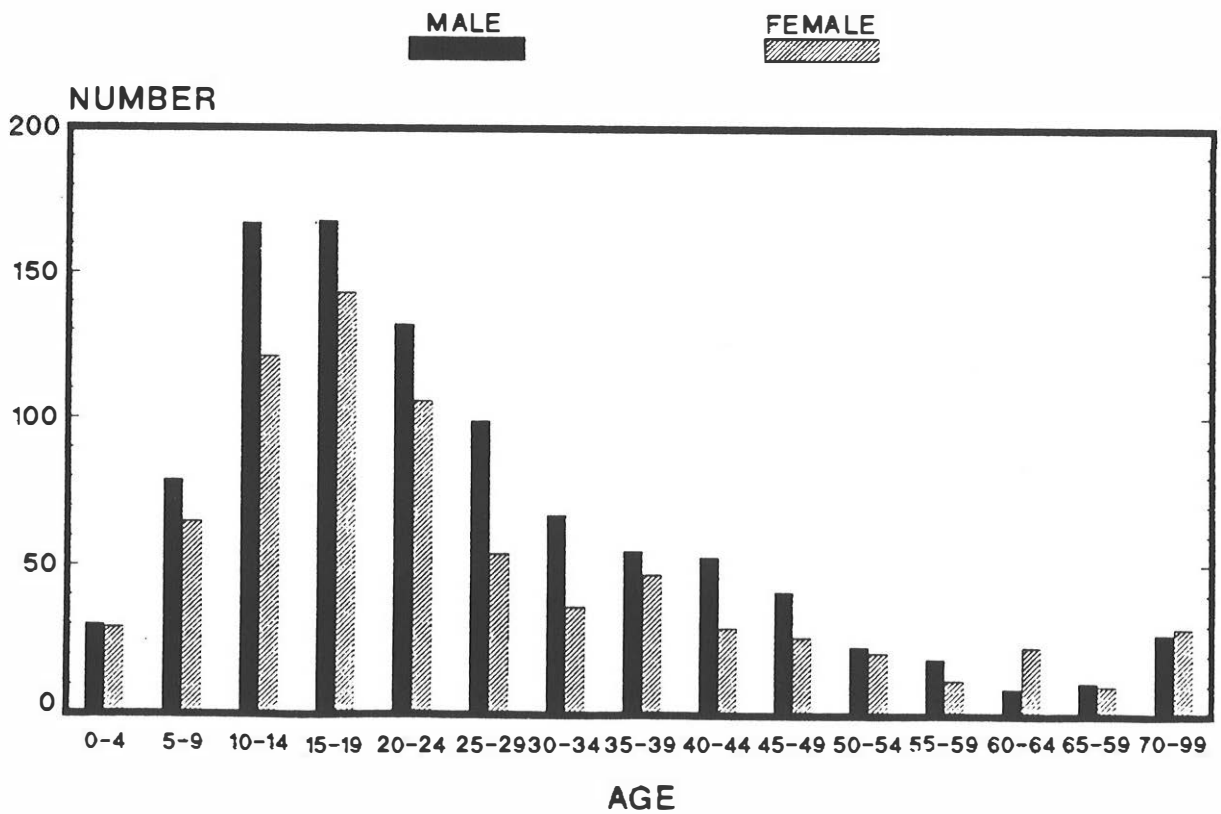


Table 2:
Age- and sex specific incidence rates for bicycle accidents in the city of Odense 1989.

	MALE			FEMALE		
Age	**N**	**Pop. 1000**	**Incidence pr.1000**	**N**	**Pop. 1000**	**Incidence pr.1000**
0-9	109	9.1	12.0	94	8.7	10.8
10-19	335	11.5	29.1	264	11.0	24.0
20-29	231	16.7	13.8	160	16.5	9.7
30-39	122	12.9	9.5	83	12.4	6.7
40-49	94	12.2	7.7	55	12.3	4.5
50-59	42	8.6	4.9	33	9.1	3.6
60-69	20	7.6	2.6	33	8.9	3.7
> = .70	27	7.0	3.9	29	11.9	2.4

Rate/ratio of sex for the different age groups:

Age	**Male/female**	**90 % CI**
0-9	1.11	0.88-1.40
10-19	1.21	1.05-1.39
20-29	1.42	1.20-1.68
30-39	1.42	1.12-1.79
40-49	1.71	1.29-2.26
50-59	1.36	0.92-2.00
60-69	0.72	0.44-1.12
> = 70	1.62	1.05-2.52

Mantel-Haenszel estimate for the **total** male/female ratio gives 1.24 (90% CI 1.14-1.35). P value < 0.005.

To reveal a possible difference in the distribution of different accident types and age, the age specific distribution of injured in two accident types is shown in Table 3.

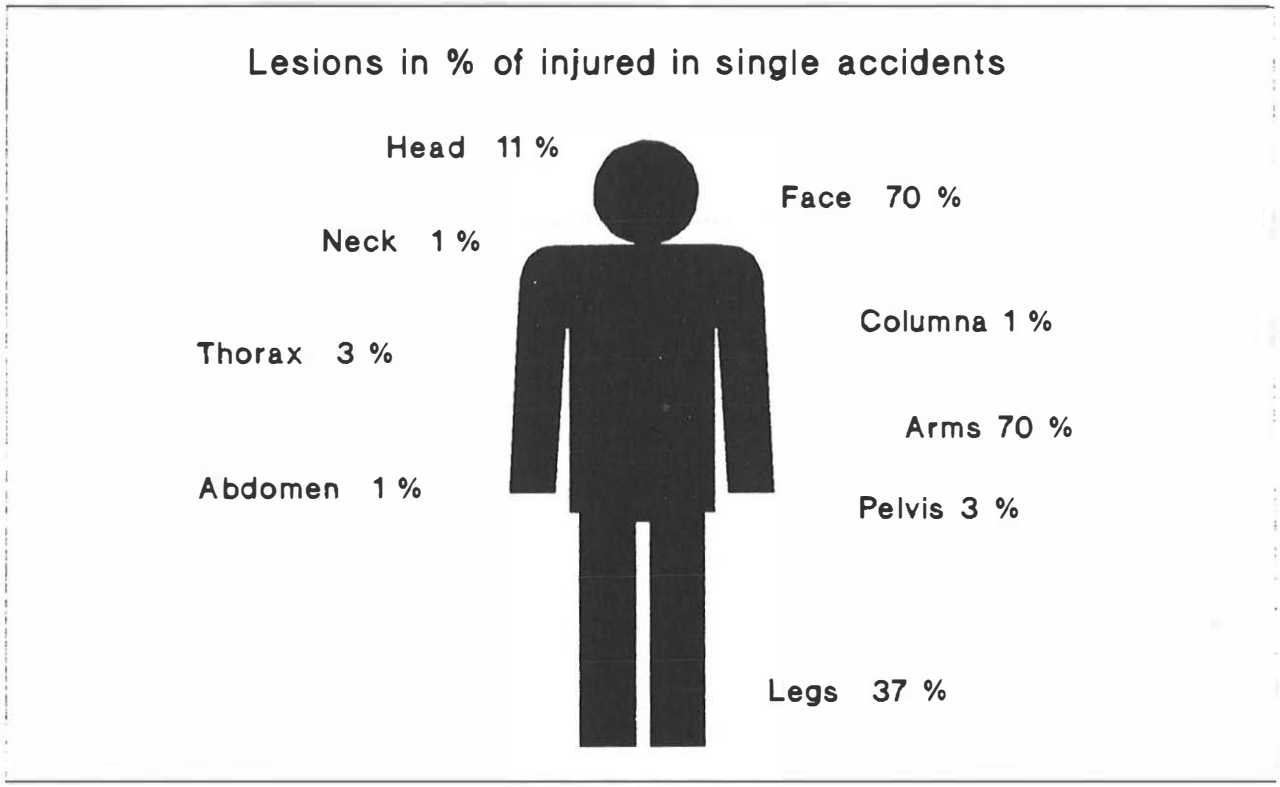
Table 3:
The age specific incidences of patients injured in two different types of bicycle accidents in **Odense 1989.**

		Single accidents		Collisions	
Age	Pop. 1000	N	Incidence Pr.1000	N	Incidence Pr.1000
0-9	17.9	157	8.77	46	2.57
10-19	22.5	382	16.98	217	9.64
20-29	33.2	247	7.44	144	4.34
30-39	25.3	147	5.81	58	2.29
40-49	24.5	102	4.16	47	1.91
50-59	17.7	46	2.60	29	1.64
60-69	16.5	41	2.48	12	0.73
> = 70	18.9	42	2.22	14	0.74

Rate/ratio for single accident/collisions for the different age groups:

Age	Rate/ratio	90 % CI
0-9	3.41	2.59-5.92
10-19	1.76	1.53-2.02
20-29	1.72	1.45-2.04
30-39	2.53	1.96-3.27
40-49	2.17	1.62-2.90
50-59	1.59	1.08-2.35
60-69	3.42	1.99-5.87
> = 70	3.00	1.81-4.98

Figure 3. Distribution of injuries in bicyclists in single accidents and accidents with a counterpart.



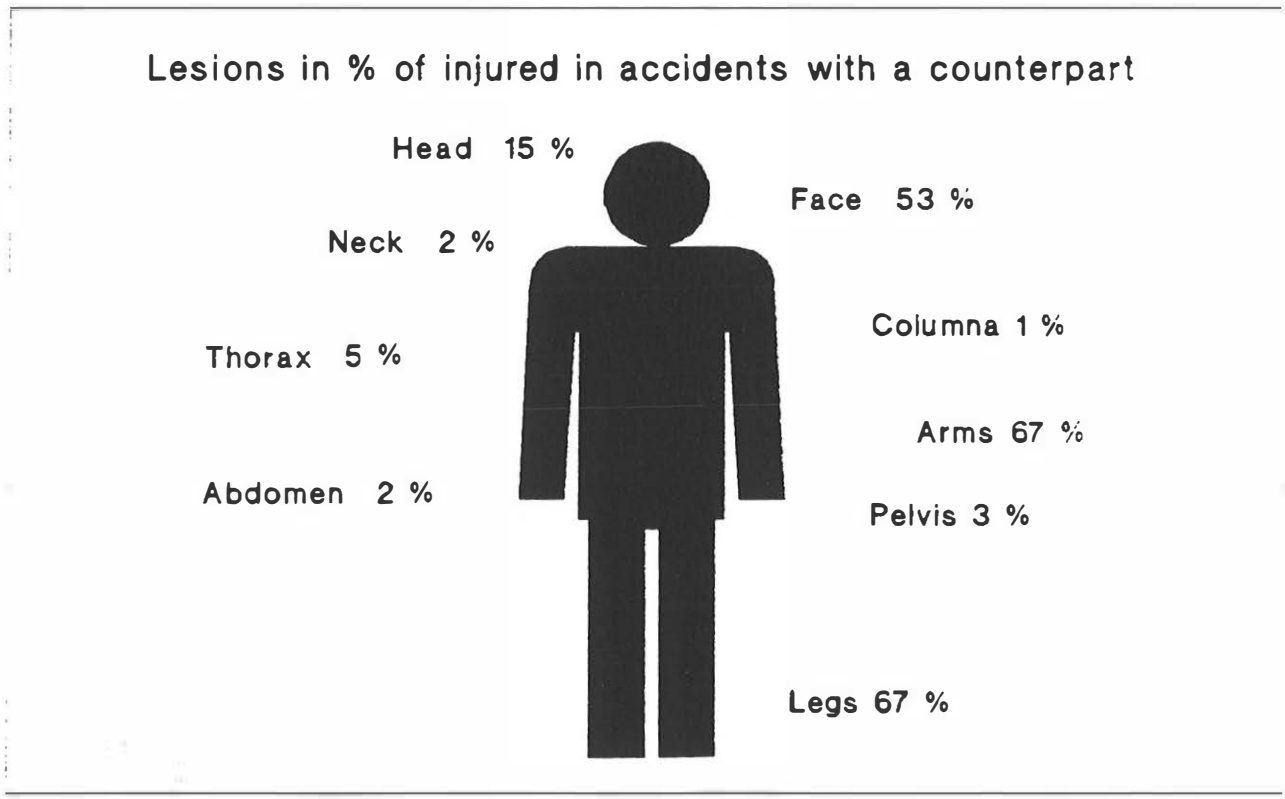


Table 4. **Distribution of accident circumstances in bicyclists' single accidents and accidents with a counterpart.**

		Bicyclists' single accidents in %	Accidents with a counterpart in %
Type of road	roadway	47.9	43.5
	protected road	5.2	2.1
	cycle track separated from roadway	21.2	30.2
	cycletrack on roadway	3.4	9.1
	coloured cycle track	0.5	2.0
	combined cycle track and footpath	8.7	8.3
	footpath	5.0	0.8
	others	7.5	3.5
	unknown	0.6	0.5
Other road characteristics			
	straight roadway	50.2	39.0
	crossing	7.9	29.1
	curve	10.7	8.9
	roundabout	0.9	1.7
	up hill	5.3	2.4
	down hill	10.4	6.6
	exit	5.1	6.3
	uphill and curve	1.1	0.4
	downhill and curve	3.2	1.5
	others	4.8	3.5
	unknown	0.4	0.6
Road surface	asphalt	80.3	92.3
	flagstone	8.8	3.6
	paving stone	1.6	0.9
	gravel	6.0	2.1
	grass	0.4	0.3
	others	2.0	0.5
	unknown	0.9	0.3
Road condition			
	dry	74.0	82.1
	wet	14.3	13.6
	ice/snow	5.7	1.1
	other	2.2	1.1
	unknown	3.8	2.1
Slippery road	yes	17.2	6.2
	no	76.8	88.9
	unknown	5.0	4.9
If yes, then slippery because of	water	4.4	2.7
	snow/ice	5.6	1.3
	gravel/leaves/mud	6.4	1.7
	other	0.5	0.5
	unknown	0.1	0.0

Table 5. **Distribution of localization and severity of bicyclists' injuries according to AIS, bicyclists' single accidents (SA), and accidents with a counterpart (CA).**

Part of the body	AIS 1		AIS 2		AIS 3		AIS 4		AIS > 4		Total	
	SA	CA	SA	CA	SA	CA	SA	CA	SA	CA	SA	CA
Head	44	38	82	39	4	6	0	4	0	0	130	87
Face	787	280	24	18	1	1	0	0	0	0	812	299
Neck	13	12	0	0	0	0	0	0	0	0	13	12
Thorax	34	20	3	1	0	4	0	2	0	0	37	27
Columna	8	7	0	0	0	0	0	0	0	0	6	7
Abdomen	7	11	2	0	0	1	0	0	0	0	9	12
Pelvis	25	18	6	1	0	0	0	0	0	0	31	19
Arms	610	308	198	64	1	8	0	0	0	0	809	380
Legs	381	334	31	34	14	9	0	0	0	0	426	377
Total	1907	1028	346	157	20	29	0	6	0	0	2273	1220

Table 6:
Severity of injuries (MAIS) among injured bicyclists according to type of accident.

	Single accidents		Collisions	
MAIS	**N**	**% of injured**	**N**	**% of injured**
1	1019	87.5	509	89.8
2	310	26.7	125	22.0
3	19	1.6	19	3.4
4	0	0.0	6	1.1
5	0	0.0	0	0.0
6	0	0.0	0	0.0
Serious lesions with MAIS > = 2:				
	329	24.4	150	22.8
Rate/ratio = 1.07 (90%CI 0.91-1.26)				
Serious lesions with MAIS > = 3:				
	19	1.41	25	3.79
Rate/ratio = 0.37 (90%CI 0.22-0.61)				

Table 7:
The age specific incidences of severely injured (MAIS 3 or more, or head AIS 2 or more) in bicycle accidents in the city of Odense.

	Male			Female		
Age	**N**	**Pop. 1000**	**Incidence Pr.1000**	**N**	**Pop. 1000**	**Incidence Pr.1000**
0-9	3	9.1	0.33	6	8.8	0.68
10-19	20	11.5	1.74	23	11.0	2.09
20-29	18	16.7	1.08	11	16.5	0.67
30-39	12	12.9	0.93	9	12.4	0.73
40-49	8	12.2	0.66	5	12.3	0.41
50-59	6	8.6	0.70	2	9.1	0.22
60-69	3	7.6	0.39	7	8.9	0.79
> = 70	6	7.0	0.86	4	11.9	0.34
Total	76	85.6		65	90.9	

Rate/ratio of sex for the age groups:

Age	**Male/female**	**90 % CI**
0-9	0.48	0.15-1.54
10-19	0.83	0.50-1.37
20-29	1.61	0.86-3.02
30-39	1.27	0.61-2.62
40-49	1.61	0.63-4.11
50-59	3.18	0.83-12.18
60-69	0.49	0.15-1.52
> = 70	2.52	0.87-7.28

Total risk ratio for male/female calculated by
Mantel-Haenszel estimate = 1.16 (90%CI 0.88-1.53)

Table 8. Answers from persons injured by single accident.

Bicycle defect	yes	3.3
	no	95.2
	unknown	1.5
Bicyclist's own fault	yes	39.2
	no	59.0
	unknown	1.8
Did you hit anything	yes	24.3
	no	73.1
	unknown	2.6
Were bad road conditions a contributing factor	yes	5.7
	no	91.4
	unknown	2.9

Table 9:
Under-reporting of bicycle accidents by age (1989)

	Single acc.		Collisions	
Age	Police reported	Not reported	Police reported	Not reported
0-9	1	194	4	27
10-19	5	519	45	179
20-29	8	283	25	111
30-39	6	157	10	54
40-49	3	122	10	50
50-59	1	63	9	20
60-69	2	37	7	9
> = 70	5	61	11	14

Rate/ratio of reporting for single accidents and collisions:

Age	Single acc. % reported	Collisions % reported	Rate/ratio
0-9	0.52	14.81	0.04
10-19	0.96	25.14	0.04
20-29	2.83	22.52	0.13
30-39	3.82	18.52	0.21
40-49	2.46	20.00	0.12
50-59	1.59	45.00	0.04
60-69	5.41	77.78	0.07
> = 70	8.20	78.57	0.10

In total the difference in reporting by the two different accident types is 0.10 (90 % CI 0.07-0.14, $p<0.005$).

Table 10:
Under-reporting by injury severity (MAIS) of bicycle accidents

	Single acc.		Collisions	
	Police reported	Not reported	Police reported	Not reported
MAIS 1	12	1144	53	401
MAIS 2	16	252	50	56
MAIS 3	1	24	12	4
MAIS 4	2	-	1	-
MAIS 5	-	-	2	-
MAIS 6	-	-	-	-

Difference in reporting for single accidents and collisions:

With MAIS> =2:
Rate/ratio of reported/not reported for single accidents and collisions = 0.12 (90 % CI 0.08-0.18)

With MAIS> =3:
Rate/ratio of reported/not reported for single accidents and collisions = 0.14 (90 % CI 0.05-0.40).

DISCUSSION

A number of research projects on bicycle accidents have been published in the past. Most studies have comprised only a small number of cases, and in investigations based on questionnaires there has been a low percentage of response. The drop-out rates have not been explained with regard to type of accident, seriousness and other parameters.

In the Accident Analysis Group in Odense we found it of interest to design a study of bicycle accidents comprising approximately 2000 cases equivalent to the number of accident victims registered in the A & E department of the Odense University Hospital in one year. The study is based on data from hospital records, and the injured persons were sent a questionnaire. With two reminders to non-respondents we made sure that the response rate was high.

In this way we were able to reach a response rate to the questionnaire of 90,2 per cent. In spite of the fact that more than 90 per cent of all the patients treated in the A & E department after bicycle accidents are included in the study we know that a number of injured bicyclists in the Odense municipality have been treated elsewhere in the community (1) (i.e. general practitioner, physiotherapist). In an investigation from Aarhus municipality (2) it was estimated that 79 per cent of the road traffic accident victims were treated at the A & E department.

Figure 1 shows the distribution of bicyclists and motor vehicle drivers and passengers from road traffic accidents registered at the A & E department over a ten year period. The number of injured bicyclists has increased, particularly in the years 1988-1989 while the number has been stagnant or has fallen lightly in the other categories. It is difficult to explain this tendency. During the past 10 years the road authorities in Odense have systematically improved the road system, and this might explain the reduction in the number of accidents involving cars, mopeds and pedestrians. Perhaps the increasing number of bicycle accidents might be explained by an increasing number of bicyclists. In the literature we have not found similar materials with the same tendency. The road- and environment department of Odense Municipality has shown a close correlation between more expensive public transport and an increase in the number of bicyclists in repeated road-side countings.

Figure 2 shows the distribution of bicycle accidents according to age and sex of the injured. There is a pronounced peak in the age group 10 - 19 years. This refers particularly to the males, while the peak regarding the females occurs some years later. Previous investigations have shown the same tendency (2, 4, 5, 7, 8, 9).

Because of the age distribution the study is well founded in the younger age groups. However, the older age groups are smaller in numbers and thus less founded in the study. To improve the latter the number of questionnaires could be extended in the older age groups by carrying out a stratification extending the materioal with another one year period, only including injured bicyclists of age 20 years or more.

In Table 2 the age and sex specific incidences of bicycle accidents are shown in ten year age groups. It seems obvious that preventive measures should be directed towards the 10 - 19 year olds in order to reduce the number of bicycle injuries. In a previous investigation somewhat lower incidences were found with a heavy predominans in the boys. In the 7 - 14 year old boys an incidence of 16,7/1000/year was found, while the maximum in the girls was 7,6 in the same age group (3). But it could be that between two countries or regions some differences could be seen. For the age groups as a whole there are 25 per cent as many males as females.

In Table 3 the incidence has been distributed according to ten year age groups and whether it was a single accident or there was a counterpart. Figure 3 shows the same for single/counterpart accidents. The accumulation of accidents in the younger age groups is due to their large number of single accidents. Accidents with a counterpart are more evenly distributed in the age groups. In all age groups there is a clear overweight of single accidents. Previous Danish investigations have shown the same age distributions in single accidents (2,4). Incidences have not previously been calculated in collision accidents, and consequently it has not been possible to compare our results with earlier studies.

Some of the external contributory accident factors regarding the traffic road are shown in Table 4. They have been distributed according to two types of accidents, namely single accidents and accidents with a counterpart. The table shows that collision accidents more often happen on bicycle paths than single accidents, and more often in crossings. One explanation for the rather large number of collission accidents on bicycle paths away from road crossings could be that they are collissions between two bicyclists or a bicyclist and a pedestrian. A Swedish study showed that 10 per cent of al collissions were collissions between two bicyclists, and that they most often occurred on a bicycle path away from road crossings (5). Single accidents most often occur on roadways/-streets or protected roads and most often on straight roadway. In both types of accidents they most often occur on dry asphalt. In single accidents the road surface is slippery in 17 percent, and in collission accidents in 6 per cent of the cases.

A distribution of the localization and severity of the lesions sustained is shown in Table 5 distributed into single accidents and accidents with a counterpart. In both groups there is a overweight of AIS 1 and 2 in the face and in the upper and lower extremities respectively. The more serious injuries according to AIS 3 and 4 are not unexpectedly found in the collission accidents.

Figure 3 shows the distribution of injuries according to body region and distributed on single accidents and accidents with a counterpart. There is no significant difference in the localization of injuries. However, in collission accidents there is an overweight of injuries to the head in opposition to the face in single accidents. This might be an indication of a larger number of concussions sustained in collission accidents. It also appears that in collission accidents the victims sustain injuries in the lower extremities twice as often as in single accidents. In single bicycle accidents 70 per cent of the injured had lesions in the face and 70 per cent in the upper extremities.

To illustrate the seriousness of the injuries sustained in collission accidents
we estimated MAIS (Maximum AIS in a body region) for the two types of accidents as the percentage of the total number of injured in the group. MAIS 3 was found in 3,4 per cent of the collission accidents, and in 1,6 per cent of the single accidents. Accordingly the percentages were 1,1 and 0 in MAIS 4. If injuries with MAIS > = 2 are regarded as more serious there is no statistical difference in the two accident types. But if the limit is raised to MAIS > = 3 there is nearly three times as many collision accidents than single acidents. This indicates that in spite of a larger number of single accidents the lesions sustained in collissions tend to be more serious.

Table 7 shows the age specific incidences for the serious lesions. Serious lesions are defined as MAIS 3 and above or AIS 2 and above for injuries in the head and brain. The incidences are divided according to the two sexes. In the age group 10 - 19 years the incidence rate is almost twice that in the other age groups. For the serious lesions there is no statistical difference between the two sexes. In numbers this material is smaller however, and there is a larger statistical variation in the incidence rates.

Previous English studies (6) have shown that the bicycle itself has had great influence on the accidents. After having experienced a bicycle accident 24 per cent were of the opinion that a defective bicycle had been a major factor. In our questionnaire only 3 per cent indicated that a defective bicycle had influenced the accident.
In the same study 37 per cent of the bicyclists as such indicated that they themselves were to blame for the accident. This is in accordance with our results (Table 8).

In Table 9 the official police data have been compared to the hospital emergency room data according to age and type of accident (single or collission accidents). Several previous studies have shown substantial under-reporting in the official road accident statistics. In the article mentioned above from England this is particularly evident in the group of single bicycle accidents. We found that the police only reported 0.5 to 8 per cent of the single accidents while 14 to 78 per cent of the collision accidents were reported. In total the collision accidents were reported 10 times as often as the single accidents with data from the emergency room as basis.
Amongst the 1.467 single accidents only 31 could be found in the police register while 121 out of 585 collission accidents were registered by the police. Part of this can be explained by the fact that children account for a large number of the single accidents, and a number of their accidents occur in

playgrounds and other places where the police cannot register the accident as a road traffic accident. One would assume that although not all bicycle accidents were registered by the police the more serious ones certainly would be. Therefore we divided the injuries sustained into degree of severity according to MAIS and type of accident and made an assessment of the under-reporting. The level of reporting is highest in the collission accidents whereas in single accidents with MAIS 2 only 16 out of 268 are reported. With MAIS 3 only 1 out of 25 was reported by the police. This shows that a large number of the serious lesions sustained in single accidents are not reported by the police.

CONCLUSION

The aim aim of this study aim of this study was to establish a basis for accident prevention and **the** conclusions are as follows;

The largest number of bicycle accidents occur in the age group 10 - 19 years with 25 per cent overweight in the males. The same age group also has an overweight of the serious lesions;

"Single accident" is the most frequent type of accident;

The most frequent bicyclist's accidents happen on straight roadway with dry asphalt;

Bicycle defects or bad road conditions do noy play a major role in the accidents according to the injures bicyclists themselves;

Lesions sustained in collision accidents are more serious than those sustained in single accidents;

For preventive programmes it is necessary to use data collected in hospital emergency rooms because the official statistics are insufficient also for the more serious lesions, and especially for single accidents.

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