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AN EXCESS OF PEDESTRIAN INJURIES IN ICY CONDITIONS: A HIGH-RISK FRACTURE GROUP—ELDERLY WOMEN

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Abstract—An "icy condition epidemic" has been analyzed in an investigation of patients treated in the casualty department of Odense University Hospital; it was found that the victims were mainly comprised of pedestrians and that the pedestrians had 14 times more injuries than during a normal winter period. Details of the accidents and definition of the high-risk groups were made possible by the routine registration of various data and by means of interviews of the patients. The difference in the risk of various injuries between the icy condition and normal winter periods are given as odds ratios (OR). The frequency of fractures, in comparison to the remainder of the winter period was found to be almost doubled. Fractures comprised 67% of the injuries against a normal 38%. The most pronounced increase was in fractures of the wrist, shoulder and hip with an OR of 3, 6 and 6 respectively. The high-risk group comprised women 50 and over, in contrast to the rest of the winter period where younger men prevailed. The investigation indicates that pedestrians have a need for prophylactic measures including (1) broadcast warnings of icy conditions both on the radio and T.V. on days of high risk, (2) more extensive clearing of the snow, and (3) spreading of sand, and possibly salt, on footpaths and bicycle paths. Specific measures should be launched to help the elderly during such periods, in order that outdoor activities may be cut to a minimum.

Traffic risks in association with icy conditions with special reference to drivers are well known and generally accepted, so that preventive measures such as radio announcements and the spreading of sand and salt, are commonly taken [Road Directorate, 1977 and Road Directorate, 1979]. On the other hand, little attention has been paid to the problems of the pedestrian. Pedestrians are not directly warned on the radio, and the problem of injuries resulting from falls has only been studied in one previous report with regard to the qualitative and quantitative composition of those attending a casualty department on well-defined days with snow and ice [Ralis, 1981].

On the 31 January, 1980, there were 14 times as many pedestrians as usual attending the casualty department of the Odense University Hospital. Pedestrians comprised the greatest number requiring attention and included those with the most severe injuries. Seven road accidents occurred on the day in question resulting in 11 contacts to the casualty department. Of these, only one required admission to hospital and there were no deaths. In contrast, 115 pedestrians were injured as a result of falling and of these 19 needed hospitalization. Therefore, this day, which was meteorologically well-defined, was studied in order to give a qualitative and quantitative measure of the extent of the injuries sustained by pedestrians in icy conditions. An attempt has been made to define the high-risk groups, as well as to estimate the increase in risk of the particularly relevant lesions comparing those injured on that day to a comparable group of pedestrians with regard to sex, age and diagnoses. The aim of this study was partly to characterize the high-risk groups, and partly to stress the importance of measures directed at reducing the accidents of these groups.

METHODS

Data regarding the accidents of those attending the casualty department of the Odense University Hospital are routinely collected. The following data were extracted for January and February, 1980: sex, age, diagnosis, and place and circumstances of the accident. The diagnoses included N-numbers 800–929 [(WHO, International Classification of Diseases, 1965)]. The place at which the accident occurred included roads, public footpaths and pavements, and the persons were pedestrians, although pedestrians involved in traffic accidents were excluded.

In addition to these routine data, further enquiries were made during an interview carried out by the authors, partly employing the telephone and partly as personal interviews in those

cases where it was impossible to contact the person by telephone. These interviews were guided by a standard questionnaire and included questions regarding the place of the accident, whether the accident occurred on the pavement, bicycle path or in the road, whether or not the site had been cleared of snow, whether sand had been put down or salt spread over the area, as well as the type of footwear worn.

Information regarding the meteorological conditions was obtained from the Climatological Department of the Danish Meteorological Institute and included daily measurements of the temperature, precipitation and height of snow at a weather observation post 10 km South of Odense during the period January and February, 1980.

The period of daylight varied during the period from 7 hours and 8 minutes to 10 hours and 37 minutes. On the 31 January the period of daylight was 8 hours and 33 minutes.

The temperature was measured three times per day (8 a.m., 2 and 9 p.m.). The precipitation was measured in mm of water daily and the height of the snow daily in cm. In 1980 the precipitation in both months was below average, in January 24 mm of water (average 50 mm) and in February 32 mm of water (average 35 mm). The average daily temperature in January was −2.5°C, compared to an expected temperature of +0.1°C, while in February the average daily temperature was −0.8°C compared to an expected temperature of −0.1°C as shown in Fig. 1.

The 31 January was characterized first by a pronounced increase in temperature from the previous evening, followed by a sharp decrease. The snow on the ground melted and then refroze immediately prior to a new snowfall, the result being ice hidden by a cover of snow. This lead to an extreme icy condition which was not readily appreciated by the residents of the area.

STATISTICAL METHODS

The χ^2 test with Yates' correction was used in combination with the 2×2 tables. For calculation of the differences in risk between the 31 January and the other part of the period, both the χ^2 test as well as odds ratios (OR) with confidence limits indicated were computed (for details see note to Table 1) (Foldspang *et al.* 1981), where a figure above 1.0 indicates an increase and below 1.0 a decrease in risk. The differences between the observations in the present work are stated as statistically significant if the P-value was below 0.05.

RESULTS

Frequency of the accidents and lesions

During the winter months of January and February, 1980, a total of 585 pedestrians suffered injury on public footpaths, etc. of these no less than 115 (20%) occurred on the 31 January (Fig. 2) compared to an average of 8 per day during the rest of the period.

There was also a pronounced qualitative difference in the patients of the 31 January as compared to the others. 67.8% of the patients were found to be in the group 50 years and over, compared to 35.3% ($P \ll 0.01$). The sex distribution also showed a pronounced difference with 82.6% women on the 31 January vs 52.8% on the other days ($P \ll 0.01$) (Fig. 2).

The diagnostic composition of the group and the anatomical distribution of the injuries were also altered (Table 1). Of particular note was the over-representation of lesions of the upper extremities (65.2% compared to 45.1%, statistically significant, Table 1). Another obvious fact was the under-representation of head injuries and lesions of the lower extremities (10.5 vs 19.4% and 18.3 vs 35.3%, respectively, both statistically significant, Table 1). The proportion of fractures among all injuries was increased to 66.9% compared to 38.3% (statistically significant, Table 1); a particularly pronounced increase was observed with regard to the upper extremities, where they comprised 48.7 vs 24.5% ($P \ll 0.01$) as well as fracture of the femoral neck, which constituted 5.2 vs 1.7% of the lesions (not statistically significant, $P = 0.06$, Table 1). The fractures of the upper extremities were mainly localized to the wrist and shoulder (fracture of the distal part of the radius and ulna, 36 fractures against 63, fractures of the upper third of the humerus, 14 vs 11 fractures) (Fig. 3). Spraining of the ankle was found to be under-represented, 4.3 vs 11.9% (statistically significant, Table 1).

The mean number of diagnoses per patient on the 31 January was 1.02 compared to 1.05 in the remainder of the period.

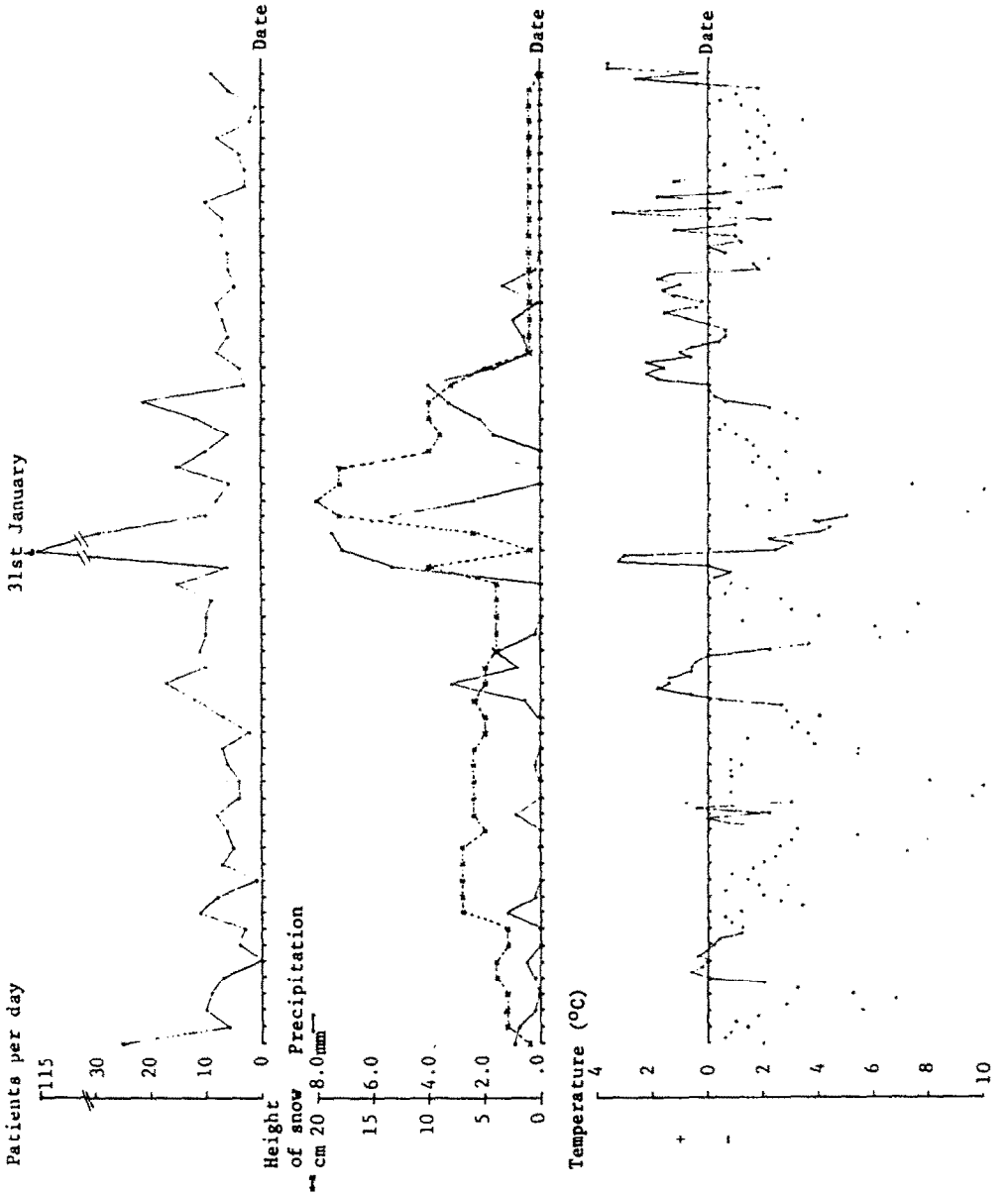

Fig. 1. The number of injured pedestrians, the height of the snow on the ground (measured in cm), the amount of precipitation (measured in mm of water), and three temperature measurements (8 a.m., 2 and 9 p.m.) for each day in the period 1 January to 29 February, 1980.

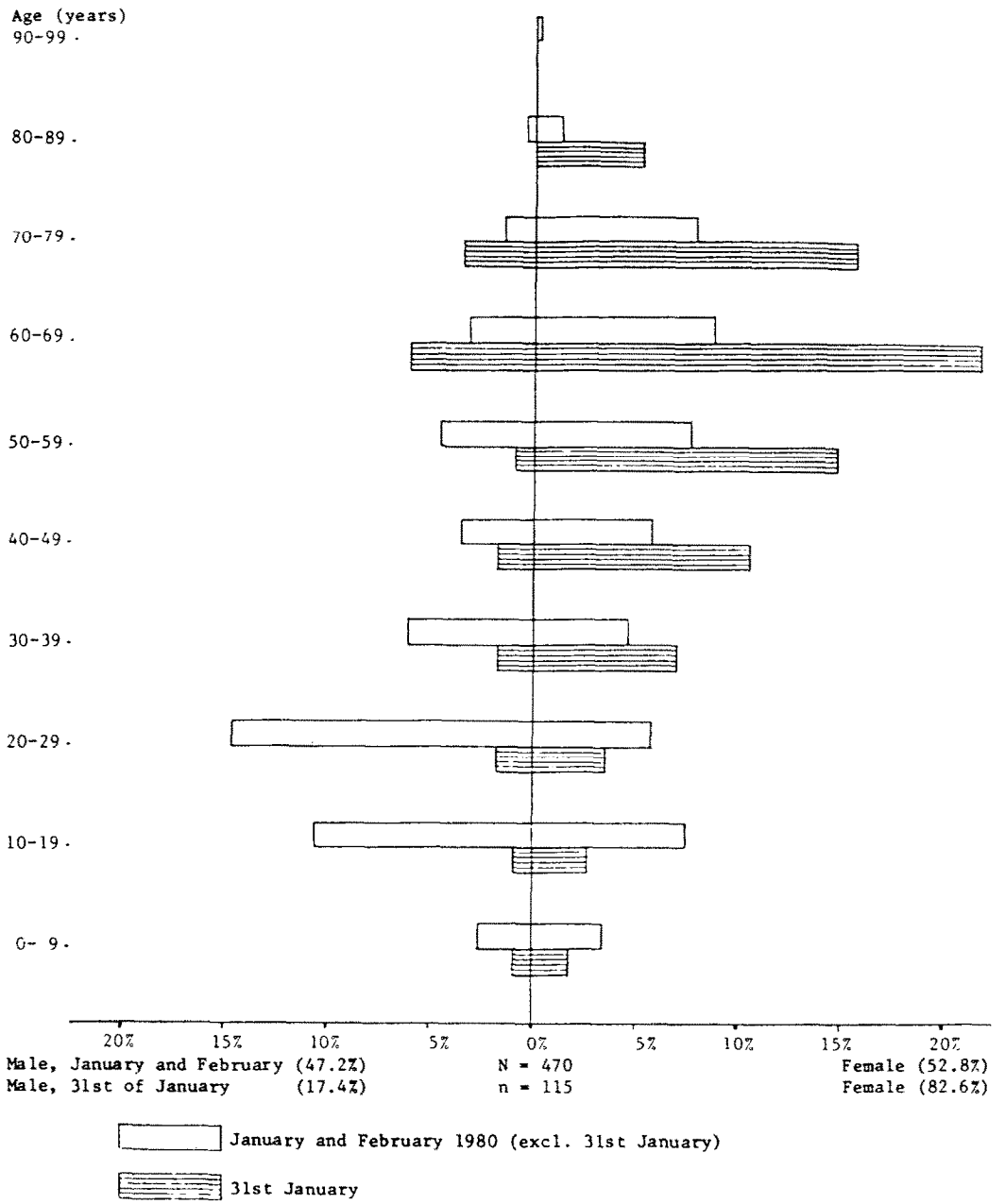

Fig. 2. Percentage distribution of injured pedestrians by age and sex. Pedestrian accidents in January and February, 1980, with the 31 January shown separately.

Nature of the accidents

Interviews guided by a questionnaire were carried out among the 115 pedestrians who were injured on public foot paths, etc. on the 31 January. These interviews were carried out during the period 10 June 1980–21 January 1981, by the authors, either as telephone interviews or, if this was impracticable, as personal contacts. One-hundred and ten interviews were obtained in this manner (96% of the group), four of the patients did not wish to participate, and one had died from cancer of the lung in the meantime.

Ninety-seven per cent (107 patients) had slipped and 3% (3 patients) tripped. The site of the accident had not been swept of snow in 88 cases (80%), no sand had been spread in 106 (96%) and salt had not been used in 103 (94%). Ninety-three patients (85%) wore footwear with flat heels, in 96 (87%) rubber soles were employed and of these 76 were patterned.

Sixty-nine patients (63%) had fallen on the pavement, 20 (18%) in the road and 21 (19%) at other sites (i.e. bicycle paths, curbs, parking lots, etc.). Very few of those questioned had noticed whether the road was better swept or had sand or salt applied compared to the

Table 1. Pedestrian accidents in January and February, 1980, compared to the 31 January. The risk is stated as an odds ratio (OR); in addition the P-value is given to illustrate the difference between the day and period

	Odds ratio*	Chi square	P values
Injuries, head total	0.5 (0.2-0.9)	4.5	P = 0.03
Injuries, trunc (incl. clavicle, scapula, pelvis)	1.8 (0.7-4.7)	1.5	P = 0.22
Injuries, upper extrem. total	2.3 (1.5-3.5)	14.2	P < 0.01
Fractures, upper extrem. total	2.9 (1.9-4.5)	25.0	P << 0.01
Fractures, humerus	5.8 (2.7-12.6)	19.5	P << 0.01
Fractures, wrist	2.9 (1.8-4.7)	19.8	P << 0.01
Fractures, hand	0.6 (0.2-1.6)	1.0	P = 0.29
Injuries, lower extrem. total	0.4 (0.2-0.7)	11.9	P < 0.01
Fractures, lower extrem. total	1.4 (0.7-3.1)	0.8	P = 0.38
Fracture, femoral neck	3.2	3.5	P = 0.06
Fracture, femoral neck and/or pelvis	4.9	10.2	P < 0.01
Fracture, malleolus	0.7 (0.1-4.0)	0.2	P = 0.69
Sprained ankle	0.3 (0.1-0.9)	4.9	P = 0.03
Fractures total	3.3 (2.1-5.0)	29.7	P << 0.01

*Odds ratio:

	31 January	January & February (excl. 31 January)	
			Sum
Occurrence	a	b	a + b
Non-occurrence	c	d	c + d
Sum	a + c	b + d	N
OR = ad/bc			
95% confidence limits: (set in brackets in the table)	$OR^{1 \pm (1.96/\sqrt{\text{Chi square}})}$		

pavement, and for this reason data regarding this item was unfortunately excluded.

Of those questioned, 72 (65%) were carrying something in their hands at the time of the accident and 42 (38%) stated that they had been able to react during the fall. One-hundred and three (94%) of the patients considered their ability to walk was good prior to the accident (i.e. they were included in the highest of Patrick *et al.* (1973) three functional levels).

The errand was considered by 69 (63%) as important and relatively urgent. The object for half of them (55 patients) was shopping or travel to or from work. Prior to the accident, a third (36 patients) considered that there was an increased risk attached to going out, due to the weather. After the accident 47% (52 patients) felt less safe and 53% (58 patients) stated that there was no change in their attitude when they went out in icy conditions.

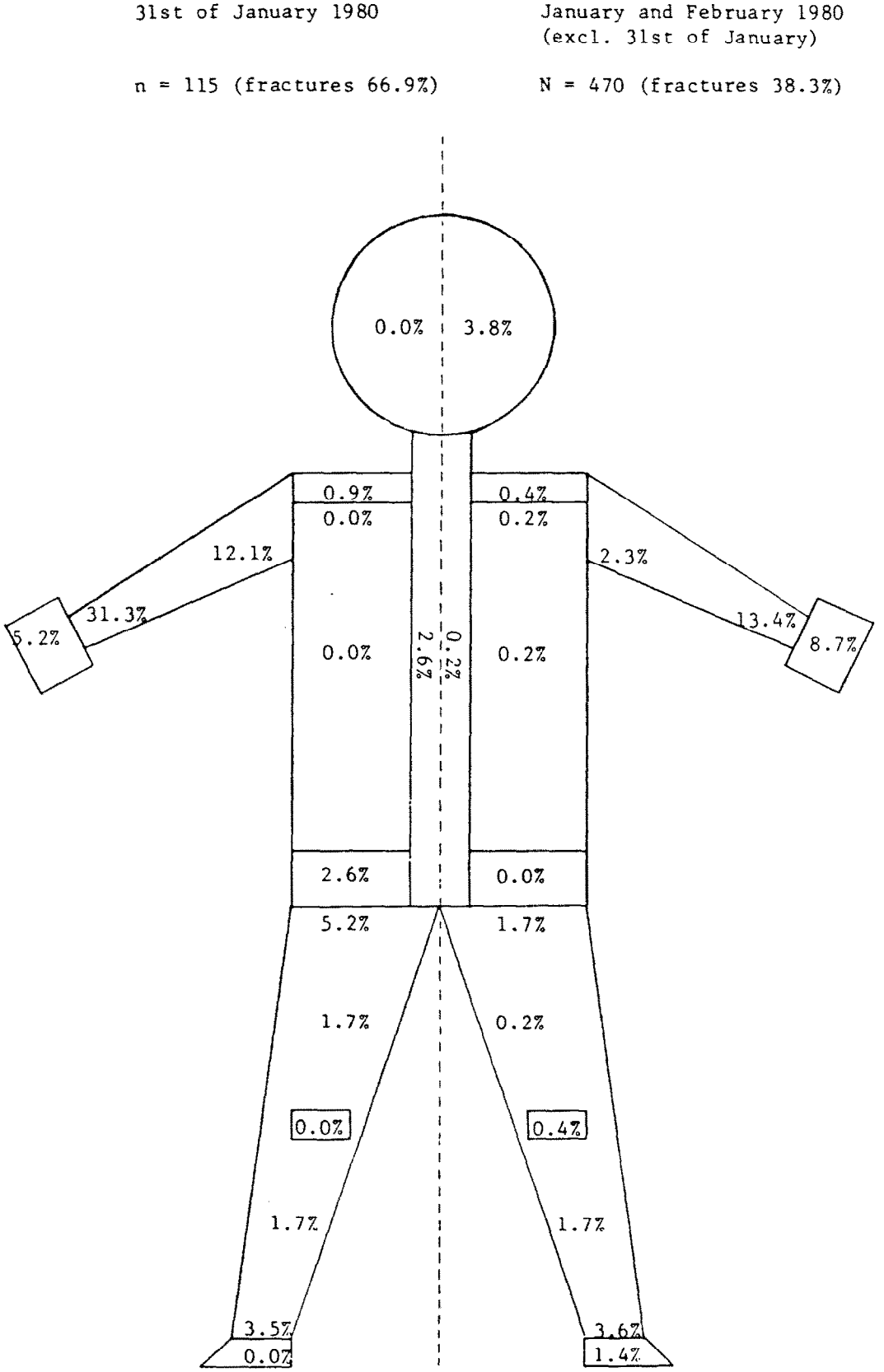

Fig. 3. Distribution of fractures stated as a percentage of the injured pedestrians. January and February, 1980, compared to the 31 January.

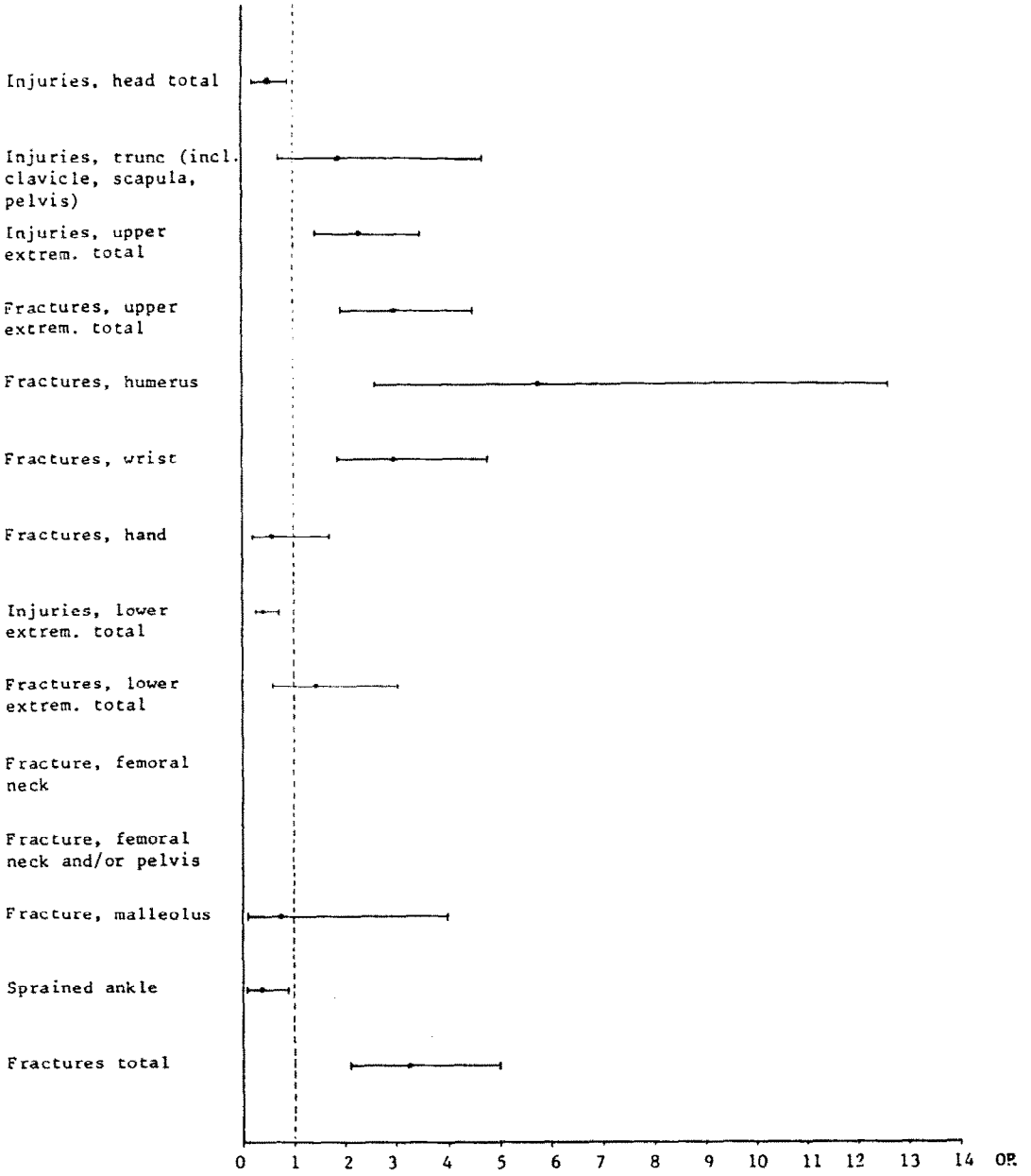

Fig. 4. Relative risk for aquiring specific lesions among pedestrians in January and February, 1980 (excl. 31 January), compared to the 31 January. Odds ratios (OR) above 1.0 indicates an increase and below 1.0 a reduction in the relative risk. The 95% confidence limits are indicated.

DISCUSSION

The difference in the composition of the patients and in factors other than the icy conditions should be reduced by selecting a winter period for the comparison. The day of investigation was in the middle of the period, so that the intensity of the light and the length of the day roughly varied correspondingly to both sides for the rest of the period. The exposure is unknown, but the number of casualties attending the department is known to vary with the days of the week [Accident Analysis Group, 1979]. The 31 January was a Thursday, the number of casualties on Thursdays normally lies in the middle of the range.

Despite the comparatively long interval between the accident and the interview the patient's recollection regarding the accident was surprisingly exact. None, apart from one, gave a time during the interview of more than 1 hour different from that noted in the hospital records.

From the present findings it seems reasonable to make some generalized statements regarding the characteristics of patients attending a casualty department on days of icy conditions, as well as of the risk of certain lesions. In general, the risk of fractures is increased among pedestrians (OR = 3) with the emphasis on patients above the age of 50 years,

particularly women (Fig. 2). The upper extremities are particularly susceptible to injury (OR = 2) with the greatest risk of fractures of the wrist (OR = 3) and fractures of the upper third of the humerus (OR = 6). Fractures of the hip region present a markedly increased risk (OR = 5) (Fig. 4). The estimates of risk must be presumed to be at the lower limits, since icy conditions were also present on other days of the period.

The pronounced increased occurrence of fractures particularly among elderly women can be ascribed to biological factors, with a reduction in strength of the bones [(Plesner, 1980)]. Reduced ability to walk was found to be of little importance with regard to the accidents in this study.

The reduced occurrence of sprained ankles (Table 1) is in our opinion explained by the fact that the accidents resulted from a decrease in friction only, so that the ankles were not affected by a torque during the fall. It should be noted that there is a remarkable redistribution of lesions in the lower extremities during icy conditions towards the proximal end of the limb (Table 1 and Fig. 3).

As Ralis [1981] we found a reduced risk of head injury (OR = 0.5), which agrees well with the observation of Barbier and Bischitzky [1969], that head injuries among pedestrians, in the main, are due to alcohol intoxication and not icy conditions.

In actual fact the day under study represents an "icy condition epidemic" [Ralis, 1981], with 14 times as many casualties per day as during the rest of the period. Even though an epidemic during icy conditions must frequently be presumed to be less serious than that of the present study, effective prophylactic measures against pedestrian accidents in icy conditions should be taken. This seems to be justified by the increased risk of fractures and the old age of the patients involved in such accidents. The general prophylactic measures should be: (1) warnings to pedestrians on the relevant icy days in radio broadcasts and television (only one-third of those injured on the day in question had any previous suspicion that there was an increased risk in walking outdoors due to icy conditions), and (2) more extensive sweeping of pavements, together with spreading of sand and the possible use of salt on the pavements, footpaths and bicycle paths. The specific prophylactic measures should be aimed at reaching the elderly as a high-risk group. Exposure to the risks should be reduced during the relatively few days when the risk is greatest by cancelling meetings and other arrangements for the elderly (a number of the elderly persons were in fact injured while on their way to meetings in pensioners' clubs). In addition, help should be offered for shopping and other necessary errands on days when icy conditions prevail. This help could be organized partly on a voluntary basis, partly by home-helpers, which a number of the elderly in our society already employ.

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