

## Retrospective analysis of fatal falls

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### ARTICLE INFO

#### Article history:

Received 12 June 2008

Received in revised form 20 January 2010

Accepted 23 January 2010

Available online 21 February 2010

#### Keywords:

Fatal falls

Head trauma

Injury pattern

### ABSTRACT

Fatal falls are frequent and inhomogeneous events and affect every age. The criminalistic classification can often only be done on the basis of extensive investigations and the autopsy results. We retrospectively surveyed 291 cases of fatal falls on which a post-mortem examination had been carried out in the institutes of Forensic Medicine in Bonn and Greifswald. In large part, these cases are falls from height ( $n = 123$ ) and ground-level falls ( $n = 122$ ). These are compared to fatal falls down a stairs ( $n = 46$ ); the analysis is confined to injuries to the cranium. In ground-level falls the injury pattern in falls under the influence of alcohol differs from that of falls with no alcohol in the case history: all injuries are seen in higher relative frequency in casualties after the consumption of alcohol. In falls from height, the previous consumption of alcohol did not influence the injury pattern; the intracranial traumas are seen in decreasing frequency with increasing heights. The aim of this retrospective analysis is to present injury patterns and influencing factors like fall heights and alcohol for the different kinds of falls on the basis of our collective and to demonstrate similarities and differences between the subgroups.

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### 1. Introduction

Not only because of their frequency but also with regard to their inhomogeneity, fatal falls are an interesting field. In clinical medicine as well as in forensic medicine, injuries as a result of falls constitute a non-negligible percentage of patients and post-mortem examinations. In the community, falls pertain particularly to elderly people. About one third of people over 65 years of age happen to fall each year, with even higher numbers in institutions [1]. Medical attention is necessary in approximately one fifth of the fall incidents [1]. In elderly people fall-related injuries are associated with considerable morbidity and mortality and constitute a major public health problem [2]. In the time period investigated, the years 1992–2003, the Federal Statistical Office numbers the annual rate of fatal falls between 11,978 and 7099 with clearly decreasing tendency (<http://www-genesis.destatis.de/genesis/online/online>). With regard to different forms of falls, the frequency of occurrence peaks in various age groups. For people of all ages, falls are the second leading cause of accidental death and the leading cause for people 79 years old and older [3]. In a collective of fatal ground-level falls with head injuries and a prevalence of old-aged people, in 77% of the cases a significant pre-existing natural disease was present [4]. Apart from illnesses, the use of psychoactive drugs was a predictor of falls [5,6]. Furthermore, alcohol contributes to the unintentional-injury deaths including falls [7]. In high-level falls mortality significantly increased with

advanced age [8,9]. Particularly in casualties advanced in years the classification of falls as cause of injuries and death respectively or as a result of a disease often cannot be done without further knowledge of the circumstances and an autopsy. Only after the clarification of fact, can the manner of death be correctly assessed. The inhomogeneity of falls extends to the forensic issues. The questions that have to be answered by forensic medicine differ according to the kind of fall. Effort has already been attended to the issue of injury patterns and various kinds of trauma [10] as well as to biomechanical reconstructions [11,12]. Further effort was put on a possible discrimination between falls and blows by the location of the injury, and the so-called hat-brim line was introduced therefore. The hat-brim line describes the largest circumference of the skull, where a hat usually comes to sit. Prokop and Radam considered the hat-brim line useful [13], whereas Ehrlich and Maxeiner could not detect differences in the location of external injury marks on the head in various types of blunt trauma [14,15]. Madea and Preuß [16] report on a preponderance of craniocerebral injury, thoracic trauma and fractures of the upper extremities in undirected, accidental falls compared to suicidal falls. Hein and Schulz [17] compared the impacted sites of the skull in different falls with respect to the influence of alcohol. The previous consumption of alcohol is another issue regarding to fatal falls. Indications given in the literature reach up to nearly 50% of the tested cases in ground-level falls [4]. Regarding the presence of alcohol in the overall accidental and suicidal fatalities, 48.6% of unintentional-injury cases and 35.3% of suicides happened under the influence of alcohol [18]. In falls from height, various statements about the relation of accidental and suicidal falls are found in the literature: Taking some unclear cases

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**Table 1**  
Different forms of falls in the collective (n=291).

	n
From height	123
Ground-level	122
Bed	9
Agonal	3
Unknown	34

into account, the percentage of suicidal falls ranges between 11% and 63.5%; accidental falls occur in 33.8% up to 89% [19–23]. The big ranges can to some extent be explained by cultural differences in life style and obviously in the choice of the suicide method.

The aim of this retrospective analysis is to present the different kinds of falls on the basis of our collective of fatal falls and to demonstrate similarities and differences—including the results of a previous study on fatal falls down a stairs by Preuß et al. [24].

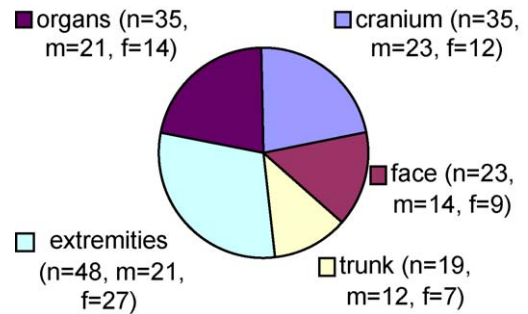
**2. Materials and methods**

All cases of fatal falls on which a post-mortem examination had been carried out in the institutes of Forensic Medicine in Bonn and Greifswald were collected. This retrospective study covers a period of 13 years, starting 1992. Prior to this analysis, fatal falls down stairs were handled by Preuß et al. [24]. Personal data like age and gender were collected as well as data relating to the fall (manner and site), to the autopsy findings (injuries, previously existing pathologic findings and cause of death), to a possible alcoholisation and as the case may be to the survival time. The collective includes 291 cases with a mean age of  $51.6 \pm 19.2$  years. Fatal falls occur in the male gender (n = 218) three times as often as in the female gender (n = 73). For the most part, fatal falls are falls from height (n = 123) and ground-level falls (n = 122) (Table 1) that are surveyed in the following. In our study, ground-level falls correspond to falls from standing heights directly to the ground. Regarding falls from a height, in none of the cases are multiple impacts depicted in the record of the post-mortem examination. Agonal falls are not subsumed under the other forms of falls. In none of the cases is any kind of head protection reported in the autopsy record. The analysis is confined to injuries to the cranium.

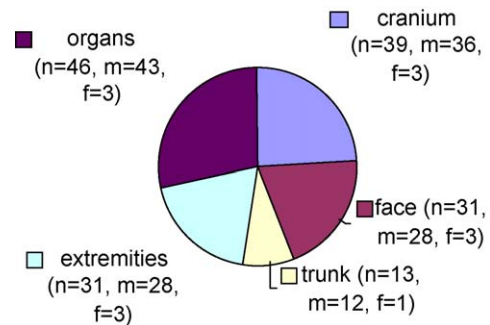
**3. Results**

**3.1. Ground-level falls**

In the overall collective 122 ground-level falls are included, of which 85 pertained to the male and 37 to the female gender. The



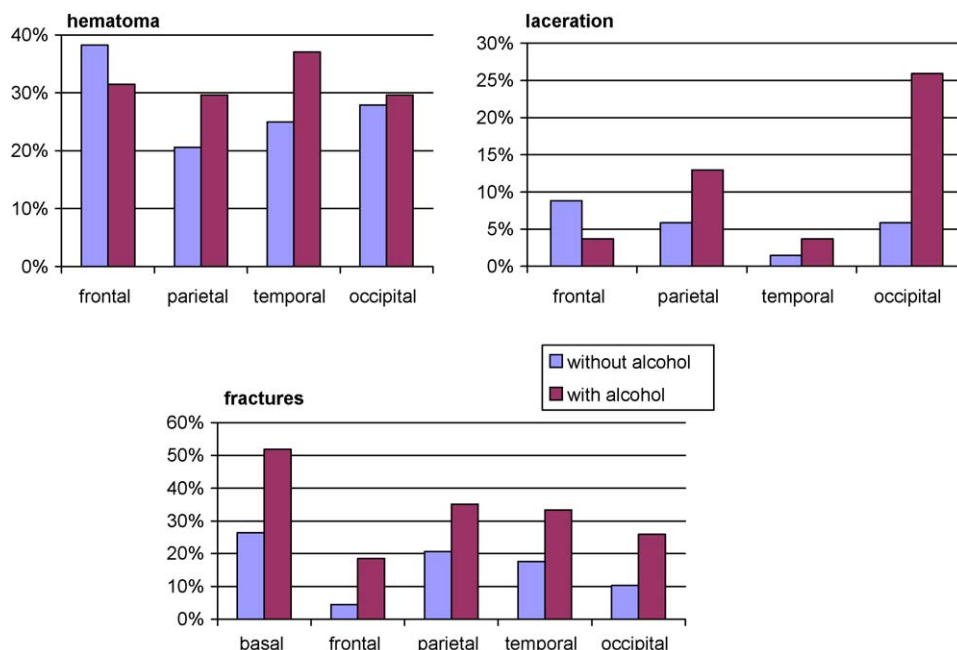
**Fig. 1.** Distribution of the injuries to the different anatomical regions in groundlevel falls—cases under the influence of alcohol (m = 50, f = 4).



**Fig. 2.** Distribution of the injuries to the different anatomical regions in groundlevel falls—cases with no alcohol in the case history (m = 35, f = 33).

average age of the male collective ( $51.4 \pm 16.8$  years) varies significantly from the average age of the female one ( $72.0 \pm 15.8$  years). Compared to the male gender, the female collective shows a greater homogeneity regarding the age distribution.

About eighty percent (77.9%, n = 95) of the ground-level falls were not immediately fatal, but present survival times from 3 h to 349 days. Pertaining to this part of our collective, 58.8% of the men and 10.8% of the women fell under the influence of alcohol. The injury pattern in falls under the influence of alcohol (Fig. 1) differs from that of falls with no alcohol in the case history (Fig. 2).



**Fig. 3.** Relative frequencies of the various injuries to the different anatomical regions of the cranium in ground-level falls with and without alcohol in the case history.

**Table 2**  
Causes of death in ground-level falls.

	No alcoholisation (n=68)	Alcoholisation (n=54)
Craniocerebral injury (included cases of subdural haematoma)	30 (12)	37 (13)
Pneumonia	11	5
Pulmonary embolism	6	0
Exsanguination	4	6
Others	17	6

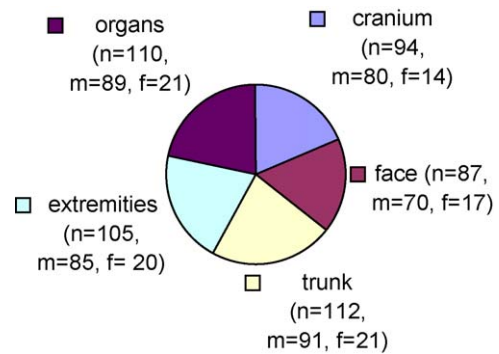
Without alcoholisation, the limbs are the most often injured part of the body; injuries to the other anatomical regions occur less frequently and in about the same frequency. In falls under the influence of alcohol the percentage of limb injuries decreases in favour of injuries to the face and the organs.

Fig. 3 shows the injuries to the cranium in ground-level falls in view of the site and the manner of the injuries. The differentiation between falls under the influence of alcohol and with no influence of alcohol is maintained. Apart from frontal haematomas and lacerations, all injuries are seen in higher relative frequency in casualties after the consumption of alcohol. The difference is particularly distinct concerning the occipital lacerations and the fractures altogether. While in cases without a previous uptake of alcohol haematomas and lacerations are most frequently seen in the frontal site, in falls under the influence of alcohol haematomas are most often found in the temporal site, lacerations in the occipital site.

The most frequent cause of death in ground-level falls altogether is craniocerebral trauma followed by pneumonia (Table 2). "Others" subsume less frequent, individual causes of death like meningitis, tension pneumothorax, rhabdomyolysis and cerebral hemorrhage.

### 3.2. Falls from height

In our collective 123 individuals died of the after effects of falls from height; 100 of those were male, 23 female. The average age of this part of the collective was  $43.1 \pm 17.3$  years and there was no significant difference in the average age of the male ( $43.1 \pm 17.3$  years) and the female ( $41.0 \pm 22.5$  years) collective. 34 of the falls were classified as suicide (27.6%, 22 male and 12 female suicides). Thirty falls from height occurred under the influence of alcohol with a



**Fig. 4.** Distribution of the injuries to the different anatomical regions in falls from height (m = 100, f = 23).

clear prevalence of the male gender (m = 27, 27.0%, f = 3, 13.0%). In falls from height, the previous consumption of alcohol did not influence the injury pattern. The different anatomical regions are affected in about the same frequency (Fig. 4). 45 cases were survived in the first instance and up to 172 days. The heights of the falls ranged from 1.5 m to approximately 100 m.

An itemisation of the injuries to the cranium is shown in Fig. 5. Haematomas are most often seen in frontal site, while there is a prevalence of the fractures in basal site. With regard to the distribution to the affected sites the frequencies of the various injuries are in no accordance.

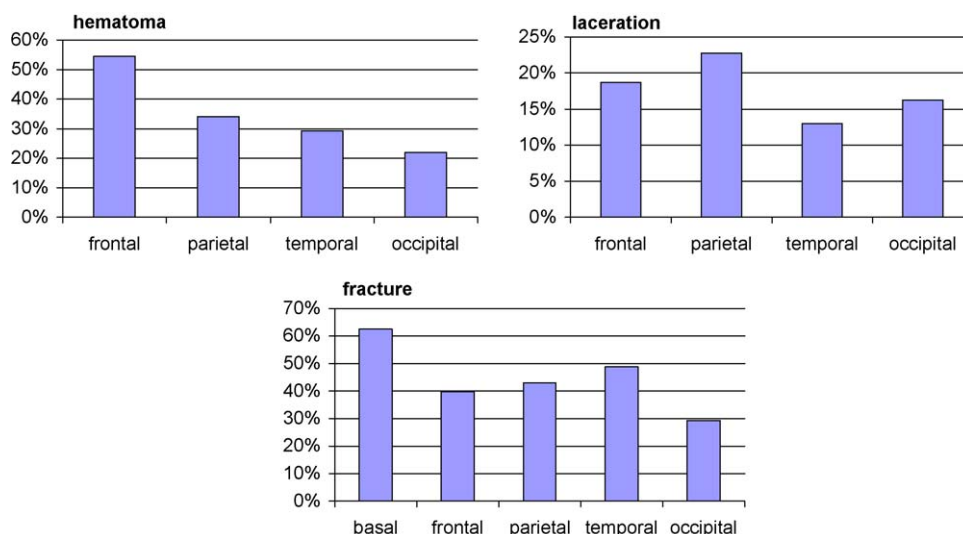
Fig. 6 shows the relative frequencies of injuries to the cranium in relation to the heights of fall. The incidence of intracranial injuries decreases with increasing heights, while lacerations and fractures at first tend to occur more frequently; at heights of more than 15 m those are seen less frequently as well.

As in ground-level falls, the most frequent cause of death in falls from height is craniocerebral trauma followed by the multiple trauma and trauma to the thorax (Table 3).

To point out cranial injury patterns of the different manners of falls, their relative frequencies are comparatively displayed in Fig. 6.

## 4. Discussion

Our data shows that fractures altogether are most often seen in falls from height. In falls from height, the most frequently affected



**Fig. 5.** Relative frequencies of the various injuries to the different anatomical regions of the cranium in falls from height.

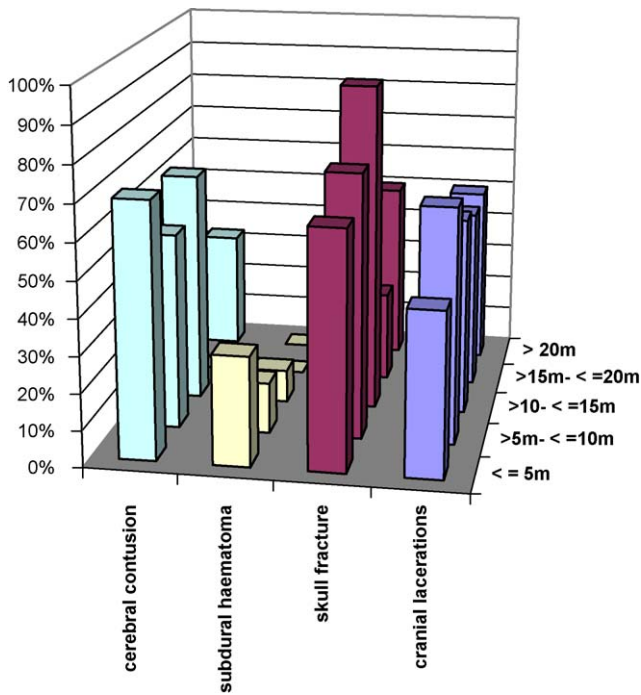


Fig. 6. Relative frequencies of different injuries to the cranium in relation to the heights of fall.

site for lacerations and haematomas are frontal and parietal. Except for the frontal site, haematomas at large occur most frequently in falls down stairs, while cranial lacerations with the exception of the occipital site are most often seen in falls from height. None of the injuries show its highest relative frequency in ground-level falls (Fig. 7).

Concordant with the results of Hein and Schulz [17] more injuries to the back of the head occur in falls under the influence of alcohol, which might have an unconstrained reason in an undamped fall backwards due to a retarded reaction. Lacerations in the occipital site are more frequently seen in alcoholised ground-level falls. The sensitivity of the influence of alcohol in ground-level falls leading to an occipital laceration is 0.78, the specificity 0.62, so that the occurrence of an occipital laceration relates to the consumption of alcohol previous to the fall. The predictive value of an occipital laceration under the influence of alcohol is rather low ( $p = 0.26$ ), the predictive value of the absence of an occipital laceration with no previous alcohol consumption high ( $p = 0.94$ ). Though, in our collective the prevalence of injuries in the alcoholised part of the collective is particularly distinct in the more severe lesions, the lacerations and fractures, while haematomas appear in about the same relative frequency in both parts of the collective.

Hein et al. [17] describe an overall frequency of basal skull fractures of 91%, while in our collective these fractures were found

Table 3 Causes of death in falls from height.

	n
Craniocerebral trauma	52
Multiple trauma	33
Thoracic trauma	13
Multi organ failure	6
Exsanguination	4
Aortic rupture	4
Pneumonia	4
Others	7

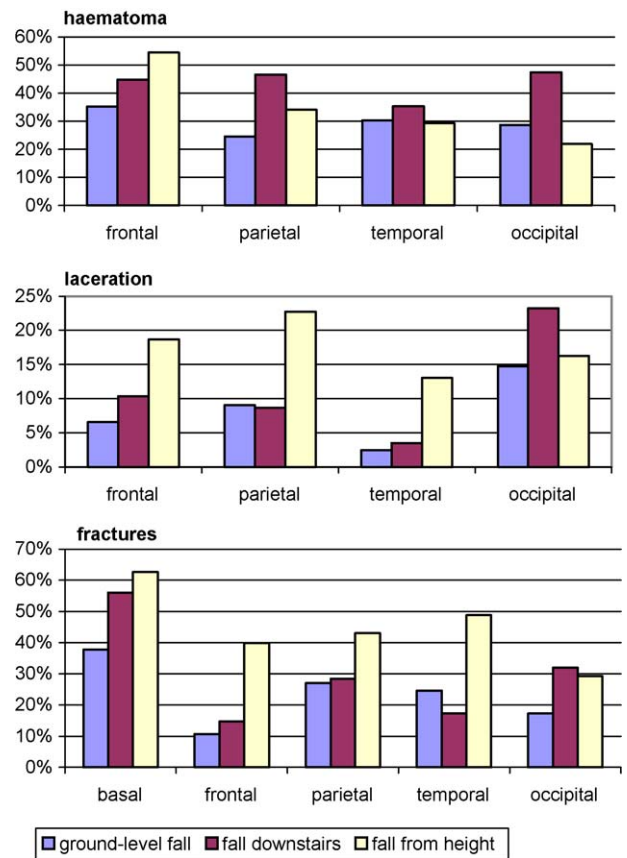


Fig. 7. Relative frequencies of the various injuries to the different anatomical regions of the cranium in ground-level falls, falls from height and falls downstairs.

in 47%. In accordance with Hartshorne et al. [4] basal skull fractures were present in about one third of the ground-level falls; with 85% in contrast to 44% acute subdural haematomas were significantly more frequently present in the collective of Hartshorne et al. than in ours. In Hein and Schulz [17] it is reported that occipital traumas happen most frequently in ground-level falls (57%) and falls that are linked to stairs (51%). As mentioned above, none of the injuries were prevalent in ground-level falls in our collective. Within the lesions in ground-level falls, lacerations show a preponderance in the occipital site, while haematomas are found only slightly more often in frontal site than in the other sites.

The distribution of injuries to the different anatomical regions in falls from height in our collective clearly differs from the results of the study by Li and Smialek [21]. While in our collective the various sites are affected in about the same frequency, Li and Smialek report a prevalence of injuries to the head and the chest, followed by injuries to the abdomen. The extremities were less frequently injured. The difference between the affected sites might arise from dissimilar fall heights; an alternative explanation could possibly be a differing distribution of the motives. In our collective suicides and accidental falls occurred in exactly the same frequency. Several cases could not be classified. The number of cases that could be assigned to either the accidental or the suicidal group and in which the height of the fall was known was too small to gain valid data regarding to differences in injury patterns. The cases that were investigated by Li and Smialek showed a preponderance of accidental falls with 52% in contrast to 40% of suicidal falls.

In our collective of falls from height, the frequency of injuries to the scalp and the skull at first shows an increase with increasing heights up to 15 m, then a decrease. The intracranial traumas are

seen in decreasing frequency with increasing heights. By Turk and Tsokos a prevalence of severe head injuries is reported at heights of falls below 10 m and above 25 m [23]. In our collective the new increase in great heights was absent.

Compared to the number of fatal falls within the time period investigated the number of fatal fall cases on which an autopsy was performed is very small. For the reasons mentioned above this small share is astonishing.

## 5. Conclusion

Occipital lacerations were found significantly more often in ground-level falls under the influence of alcohol compared to falls with no previous consumption of alcohol. The sensitivity therefore was 0.78, the specificity 0.62. In ground-level falls, the average age of the male and the female part of the collective vary significantly with a clearly higher average age and a greater homogeneity of the female gender. In falls from height, there was no difference in the average age between the genders observable. Injuries to the head show occurrence in increasing frequency up to 15 m and show a decrease then with greater heights. No injury patterns that would significantly differentiate between the various manners of falls could be elaborated by dint of our collective.

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