

# WORK-RELATED INJURIES AMONG FIREFIGHTERS: SITES AND CIRCUMSTANCES OF THEIR OCCURRENCE

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**Abstract.** The aim of the present study was to determine the injury ratio, causes and duration of temporal work disability from on-duty injuries among firefighters, taking into account the site and circumstances of their occurrence. The study was performed on a representative sample of 1503 firefighters from 29 fire stations who were employed between 1994 and 1997. Subject to investigation were data on the number of days and cases of work disability due to on-duty injury, personal data (age, work duration) and data on the circumstances of injury during emergency operations, taking part in compulsory physical training, performing maintenance and repair works, on duty at the fire station, and when commuting to or from work. The analysis of work-related causes and circumstances of injuries among firefighters revealed that the majority of injuries (40%) occurred during compulsory physical training, being responsible for 41% of post-injury absence at work. The workers employed for less than one year were at highest risk of injury. Injuries during emergency operations made 25% of all injuries and accounted for 24% of post-injury absence. The analysis of data showed that the frequency of injuries was not significantly aged-dependent, however, the duration of work disability was found to increase by 20% with increasing age of workers. The results indicated the need for undertaking preventive interventions to minimize occupational hazards to those involved in firefighting.

**Key words:**

Work-related injuries, Temporary disability for work, Firefighters

## INTRODUCTION

The nature and conditions of work performed by firefighters pose serious hazards to their health and life. The main problems arise from exposure to multiple physical (physical and thermal workload) and chemical (toxic chemicals) agents, as well as from particularly high level of stress experienced during emergency operations [1,2].

Considering the biochemical, physical and organizational aspects of this job, candidates for firefighters need to possess excellent qualifications, skills and physical fitness. Other essential requirements to be met are good sight,

hearing and color distinction. Any deficiency in this respect prevent a candidate from working as a firefighter [3]. The health impairments and disorders determined by the job characteristics include injuries, traumas, respiratory diseases, cardiovascular diseases, lung cancer and cancers of other sites like large intestine, bladder or kidney [4–6]. Of similar significance among health effects seem to be mental disorders referred to as the post-traumatic stress disorder which develops as a consequence of a traumatic experience in a life-threatening or health-hazardous situation. This may even lead to severe health problems manifested long after original trauma [1,7–9].

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In recent years the workload of firefighters has increased considerably due to the expanded scope of their duties to include chemical, ecological and technical emergencies. Therefore, it is essential to identify possible health effects related to specific conditions of firefighters' work. This would provide grounds for undertaking a complex prophylaxis, covering both the prevention of permanent work disability and job quitting for health-related reasons.

To evaluate health effects of occupational hazards at work of rescue-squads and engine-company members, temporary disability for work due to on-duty injuries and poisonings were adopted as a parameter, which reflects the health condition of this occupational group and the severity of cases as the sickness absence always precedes transient of permanent disability for work [10–12].

The aim of the present study was to determine the injury ratio, causes and duration of temporal work disability from on-duty injuries among firefighters, taking account of sites and circumstances of injuries.

## MATERIALS AND METHODS

The study was performed on a representative sample of 1503 firefighters from 29 fire stations who were employed between 1994 and 1997 [13]. The sample was collected by stratified randomization in which strata were identified as fire stations of a defined type (A, B, C, and D). The type of the fire station depended on its size, that is on the number of firefighters employed. Within each strata a given number of fire stations were randomly allocated so that the percentage of firefighters within given stratum in the sample was equal to this percentage in the whole population of firefighters in Poland. Applying this method, 29 fire stations were selected, and all firefighters employed there in the aforesaid period were included in the study. The size of the sample resulted from the assumed indispensable number of firefighters subjected to examinations. Finally it appeared that the sample equaled to 7% of the total population of firefighters.

The data analysis involved personal records available through the human resources department and work safety services. Subject to investigation were data on the num-

ber of days and cases of work disability due to on-duty injury, personal data (age, work duration) and data on the circumstances of an injury during emergency operation, taking part in compulsory physical training, performing maintenance and repair works, on duty at the fire station, and when commuting to or from work. All the cases of injury that resulted in a temporal disability for work were analyzed both by the cause of the injury, following the International Classification of Diseases, (ICD-9) [14] and by the affected part of the body [15].

The rate of injuries and their health effects among firefighters was analyzed by age, work duration and injury circumstances, according to two parameters: (a) the injury ratio expressed as the annual number of injuries per 1000 workers, and (b) the number of days of injury-related work disability in a year per 100 workers – sick leave days ratio. Linear regression was applied to analyze the duration of post-injury absence from work. The logarithm of absence duration was a dependent variable, whereas tenure of employment as a firefighter and the age at the injury were independent variables. The incidence of injury was analyzed using Poisson regression model. Injuries were considered as statistically independent events. Both theoretical and empirical reasons counted for this approach since the observed distribution of injury cases did not differ significantly from the expected distribution. There exist no grounds for supposing that some firefighters were more prone to accidents as they were very carefully selected, taking account of their physical fitness and psychological predisposition. The calculations were made using Stata 6 software [16].

## RESULTS

At the beginning of the study period, in 1994, the mean age in the group of 1503 subjects was 32 years ( $\pm 6.5$  years). The age distribution was as follows: 43.2% of persons aged 20–29 years, 46.1% aged 30–39 years and only 10.7% aged over 40 years. According to work duration, the following groups were distinguished: less than 1 year of work – 15.6%; 2–5 years – 23.9%; 6–10 years – 26.2%; 11–15 years – 24.3%, and more than 16 years of employment – 10%.

**Table 1.** Injuries rate by injury circumstances and victim's age

| Age groups (years) | Total | Emergency operation | Physical training | Equipment maintenance and repair | Routine service | Commuting to/from work |
|--------------------|-------|---------------------|-------------------|----------------------------------|-----------------|------------------------|
| Total              | 70.3  | 17.6                | 27.9              | 7.2                              | 9.6             | 8.0                    |
| 20–29              | 73.9  | 19.9                | 30.8              | 7.1                              | 10.3            | 5.8                    |
| 30–39              | 67.9  | 15.9                | 27.1              | 7.1                              | 10.0            | 7.8                    |
| 40–49              | 70.8  | 20.2                | 24.6              | 4.3                              | 7.2             | 14.5                   |
| 50–59              | 76.1  | –                   | 30.4              | 45.7                             | –               | –                      |
| p                  | 0.855 | 0.819               | 0.842             | 0.023*                           | 0.917           | 0.358                  |

\* p &lt; 0,05

Within a 4-year period under study, 352 injuries with 301 victims were recorded. These injuries were responsible for 14 675 days of work disability. Thus, the annual injury ratio was calculated to be 70.3 injuries per 1000 workers, and the lost time rate was 293.7 days per 100 workers. The injury ratio for firefighters was found to be 7 times as high as the respective ratio for the whole national economy (except for individual farms) and over twofold in comparison with the highest rate of accidents at work observed in the mining industry. The injury-related work disability was 2.5 times higher than that for the male working population in Poland [13,17].

In the study population, injuries during compulsory physical training prevailed (40% of all the injuries). They were also responsible for the longest duration of work disability equal to 119.1 days of absence per 100 workers annually. This was followed by on-duty injuries during emergency operations (25% of injuries and 72 days of absence), on-duty activities at the fire station (13.7% of injuries and 36.5 days of absence), commuting to or from work (11.4% of injuries and 37.6 days of absence), and maintenance and repair works (10% of injuries and 28.5 days of absence). Work disability due to all these causes ranged from 10 to 13% of the total injury-related sickness absence among firefighters.

An analysis of the injury ratio by age groups revealed the lowest value among firefighters aged 30–39 and the highest among those aged more than 50 years (Table 1). However, there was no much difference between age groups, which was also evidenced by p-values. In the 30–39 age group, accidents during routine firefighting duty were also less frequent (by about 20% as compared

to younger and older firefighters). During compulsory physical training, accidents were least frequent in the 40–49 age group and most frequent among firefighters aged 20–29 and 50–59 years. Among those involved in maintenance and repair works, a six-fold increase in the accident rate relative to the average was observed in the 50–59 age group. The frequency of accidents occurring when commuting to or from work was also increased (by 80% relative to the average) in the 40–49 age group of firefighters. But the frequency of injuries was not found to be clearly age-dependent, however, the duration of work disability because of injuries increased with increasing age (Table 2). Based on the regression model, showing an association between post-injury absence and the victim's age, it was estimated that a ten-year increase in age contributed to a 20% increase in the duration of work disability. This relation was statistically significant ( $p < 0.05$ ).

When analyzing the injury rate by the duration of employment in a fire station, it was found that the highest rate applied to firefighters with very short work history, less than one year and between 2 and 5 years (95.5 and 83.7 cases per 1000 workers, respectively) (Table 3). About 70% of accidents in the former group occurred during compulsory physical training (63.7/1000 workers). During routine firefighting duty, those employed for 2–5 and 6–10 years were most frequently affected by injuries (23/1000 workers and 18.6/1000 workers, respectively). The lowest rate of accidents at work was observed among those employed for 11–15 years (59.3/1000 workers).

Not much variability with respect to the duration of injury-related temporary work disability was found in par-

**Table 2.** Duration of post-injury work disability (sick – leave days/100 persons) by injury circumstances and victim’s age

| Age groups (years) | Total | Emergency operation | Physical training | Equipment maintenance and repair | Routine service | Commuting to/from work |
|--------------------|-------|---------------------|-------------------|----------------------------------|-----------------|------------------------|
| Total              | 293.7 | 72.0                | 119.1             | 28.5                             | 36.5            | 37.6                   |
| 20–29              | 268.5 | 69.8                | 111.8             | 21.9                             | 42.7            | 22.3                   |
| 30–39              | 277.6 | 75.2                | 119.8             | 23.4                             | 36.2            | 23.0                   |
| 40–49              | 351.4 | 72.7                | 113.2             | 6.2                              | 25.6            | 133.7                  |
| 50–59              | 912.4 | –                   | 309.0             | 603.4                            | –               | –                      |

**Table 3.** Injuries rate by injury circumstances and duration of work

| Duration of work (years) | Total | Emergency operation | Physical training | Equipment maintenance and repair | Routine service | Commuting to/from work |
|--------------------------|-------|---------------------|-------------------|----------------------------------|-----------------|------------------------|
| Total                    | 70.3  | 17.6                | 27.9              | 7.2                              | 9.6             | 8.0                    |
| – 1                      | 95.5  | 10.6                | 63.7              | 5.3                              | 5.3             | 10.6                   |
| 2–5                      | 83.7  | 23.0                | 31.4              | 9.4                              | 8.4             | 11.5                   |
| 6–10                     | 66.2  | 18.6                | 23.8              | 5.2                              | 11.0            | 7.6                    |
| 11–15                    | 59.3  | 14.4                | 23.6              | 9.1                              | 6.8             | 5.4                    |
| 16 –                     | 74.8  | 15.7                | 31.4              | 6.0                              | 13.3            | 8.4                    |
| p                        | 0.151 | 0.582               | 0.027*            | 0.707                            | 0.555           | 0.660                  |

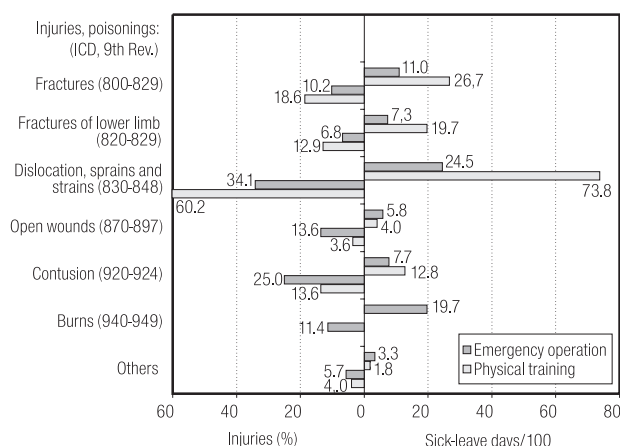
\* p < 0.05

ticular groups of workers classified by work history (Table 4). The longest period of absence from work, 353.2 days/100 workers, was recorded among firefighters with the longest employment duration. Considering all the described circumstances of injuries, the longest time off was caused by injuries occurring during compulsory physical training, which was mostly due to the high rate of such injuries. They accounted for 41% of injury-related

absence of firefighters in general, and 57% of absence among those with a work history under one year.

The high frequency and long work disability from injuries that occur both during compulsory physical training and routine firefighting duty (65% of all the injuries) have prompted us to undertake an analysis of the causes of work disability due to these injuries (Fig. 1). The most common injuries which happened during firefighting operations were: dislocations, sprains and strains of joints and adjacent muscles (34.1%), contusion with intact skin surface (25%), open wounds (13.6%) and burns (11.4%). As to injury-related absence, the former were responsible for 34% (24.5 days/100 workers) and burns for 27.4% of absence (19.7 days/100 workers). In the group of injuries at the physical training sites, the most frequent were: bone twisting (60.2%), fractures (18.6%, including 12.9% of lower limb fractures) and contusion with intact skin surface (13.6%). In all, they made up to 95% of absence (113.3 days of work disability per 100 workers).

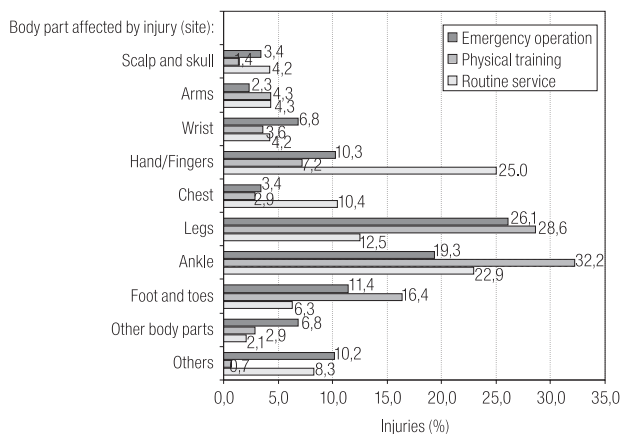
The analysis of the causes of injury by the affected body parts (Fig. 2) indicated that during emergency operations the highest rates applied to injuries of legs (26%), ankles



**Fig. 1.** Percentage of work-related injury and post-injury absence, by causes and circumstances of injury.

**Table 4.** Sick-leave days per 100 persons by injury circumstances and duration of work

| Duration of work (years) | Total | Emergency operation | Physical training | Equipment maintenance and repair | Routine service | Commuting to/from work |
|--------------------------|-------|---------------------|-------------------|----------------------------------|-----------------|------------------------|
| Total                    | 293.7 | 72.0                | 119.1             | 28.5                             | 36.5            | 37.6                   |
| - 1                      | 317.4 | 52.6                | 180.1             | 5.5                              | 33.6            | 45.6                   |
| 2-5                      | 323.2 | 52.9                | 123.8             | 45.3                             | 34.7            | 66.5                   |
| 6-10                     | 279.0 | 92.4                | 99.4              | 29.6                             | 37.6            | 20.0                   |
| 11-15                    | 248.4 | 70.9                | 95.0              | 24.8                             | 33.6            | 24.1                   |
| 16 -                     | 353.2 | 58.8                | 179.3             | 15.4                             | 39.1            | 60.6                   |

**Fig. 2.** Percentage of work-related injury, by affected body part and circumstances.

(19%) and feet (11%), while during physical training much higher rates were noted: ankles – 32%, legs – 29% and feet – 16%. The structure of injuries during routine service at the fire station was different: injuries of hands and fingers prevailed (25%), and were followed by injuries of ankles (23%), legs (12%) and chest (10%). It needs to be noted that the multiple body part injuries were ranked highest among the injuries that occur during emergency operations (7%).

## DISCUSSION

The analysis of the causes and circumstances of injuries at work of firefighters revealed that the majority of injuries (40%) occurred during the compulsory physical training activities, being responsible for 41% of post-injury absence at work. The victims were most frequently the workers with less than one year of employment. For this group, the injury ratio was over twice as high as the average. The injury-related absence in this group was mostly due to leg

injuries (38%), among which dislocations, sprains and strains of joints and adjacent muscles prevailed (78%).

The injuries during emergency operations covered 25% of all the workplace injuries in this occupational group and accounted for 24% of post-injury absence. The firefighters of the 20–29 and 40–49 age groups and those with a work history of 2–5 years were most frequently afflicted by injuries, including dislocations, sprains and strains of joints and adjacent muscles mainly in legs, ankles and feet (57%) contributing to 34% of absence. The third place was occupied by burns (11%) responsible for 27% of injury-related absence.

The data analysis revealed that the frequency of injuries was not significantly age-dependent, however, the duration of work disability was found to increase by 20% with increasing age (10 years) of workers.

The results of the study may be controversial in many aspects. But it is very difficult to refer them to the literature data. The majority of epidemiological studies carried out in the group of firefighters are based on cohort analyses of mortality. For example, an increased risk of death from injuries among firefighters was observed in the Canadian and the US studies [1,4,5]. In the Canadian study, Guidotti revealed almost a fivefold (statistically significant) increase in risk of death due to fire-related injuries [1]. The US studies showed statistically significant risk of death from accidental falls in San Francisco firefighters, as well as from accidental falls and fire-related accidents among firefighters from 27 states [4,5]. In our study no deaths from injuries were recorded, and only injuries responsible for work disability were included in the study. Work disability – sickness absence among fire-

fighters was presented by Guidotti [18], but he discussed all accidents without distinguishing them from those related to work. Therefore accident rates and numbers of days of work disability were lower from those estimated in our study (156.88 days/100 person-days vs. 293.7 days).

In the case-control study, the risk of such accidents as smoke inhalation, burns and falls depended on job positions, origin of fire, fire type and size [19]. One should also remember about another essential factor, i.e. shift work typical of this occupation. A very thorough study conducted in the German working population indicated an association between the risk of accidents at work and the distribution of working hours during a day. The risk began to increase after the 9th hour of work [9]. In our study this variable was not considered, but relying on the information provided by the State Fire Department, the largest number of accidents per day occur between 2 and 6 p.m. which corresponds with the 7th – 10th hour of work.

The comparison of accident rates between the group of firefighters and other occupational groups is also difficult because Polish statistics in this area lacks the data on the post-injury consequences. It should also be noted that such data are very scarce in the world literature as the majority of papers usually deals with fatal casualties. Therefore the results of recent studies of a cohort of Brazilian steelworkers deserve to be mentioned here [20]. Among 10 891 accidents at work registered during the years 1977–1992, there were 31% of wounds and scratches; 19% of contusion; 19% of cases with the presence of foreign body mostly in the eye; and about 10% of burns. Over 40% of accidents in steelworkers involved hands and arms, and only 16% of them legs and feet. These figures show an essential difference in the accident structure between steelworkers and firefighters. The authors report the highest accident rate among the youngest workers with the shortest duration of employment, as well as the tendency to a decreased number of accidents with increasing age and duration of employment. The Finnish study in the group of trailer assembly workers and blue collar workers differentiated sickness absence due to work-related accidents by employment duration [21]. The largest number of days of work disability due to accidents at work

was found among so called "new workers" during the second year of their employment (more absence days than during the first year), more than twice as high as in the group of workers with longer employment.

To sum up the analysis, it should be concluded that the findings of the present study, which indicates an increased rate of injuries at work among firefighters, resulting in long-term post-injury absence, have been confirmed by numerous epidemiological studies concerning this occupational group.

The results of our study are burdened with a certain sampling error caused by the random nature of the sample. But it falls within the admissible limits as evidenced by the data on accidents registered in the whole population of firefighters, for example, the percentage of accidents in one given year, occurring during emergency operation or compulsory physical and vocational training, did not differ significantly from that found in our study (20% and 36% vs 25% and 40%, respectively). Also the structure of accidents analyzed according to their consequences was similar to that in the general population (fractures and dislocations – 50%; contusions – 25%; and wounds – 13%).

The results regarding the rate of accidents during compulsory physical training as compared to that during emergency operation seem to be most controversial in view of different time of risk for accidents during these two types of activities. The problem arises from the lack of data on time devoted to firefighting actions, whereas we know that physical exercises took place every day with the participation of all firefighters, regardless of their age and duration of employment. Based on the number of actions in the whole country, it was only possible to estimate that in one selected year (1996) there was about one action/day per each fire station. The number of firefighting actions in individual years was almost the same in the study period. It seems then that the data on injuries and their causes are fairly comparable.

Following the analysis of causes of accidents, the work hygiene and safety services of the State Fire Department found that over a half of accidents result from inappropriate behavior and carelessness of firefighters themselves, and the major causes of injuries are slip, stumble, lost bal-

ance or fall. Insufficient knowledge about hazards occurring in different circumstances of duty performance, poor physical condition and lack of physical fitness among firefighters, loose conduct outside actions, insufficient equipment of firefighters with modern technical means, too much involvement in group sport and lack of warming up before physical exercises are another group of factors responsible of accidents at work.

In addition, the results of the study showed that physical exercises aimed at improving physical fitness of firefighters to prevent them from potential occupational hazards may be also responsible for injuries.

Our results render it possible to recognize the need for undertaking preventive interventions to minimize occupational hazards to those involved in firefighting. It should, however, be noted that this study is just the first attempt in Poland to assess the health condition of firefighters, and more thorough analyses are needed to identify the health determinants for this occupational group.

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