

ACCIDENTS RATE OF THE POLISH STATE FIRE SERVICE OFFICERS DURING SERVICE IN THE YEARS 2015–2022

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ABSTRACT

Background: The profession of a firefighter is fraught with a significant risk of injuries. Firefighters operate in hazardous zones to mitigate threats and combat fires. Aim of work is to evaluate the accident rate of the officers of the Polish State Fire Service in connection with their service, considering direct participation in rescue operations, and other official duties between the years 2015–2022.

Material and Methods: An 8-year analysis was conducted from reports covered the number of accidents, the number of injured firefighters, the age of the officers, the circumstances of the event, and the type and location of the injury. This includes fire and rescue operations, exercises, training, official trips, sports activities, and technical work related to equipment. **Results:** Between 2015 and 2022, there were 12 588 individual and group accidents in various circumstances. Most firefighter accidents occurred during rescue and firefighting operations, as well as during sports activities which dominate as the cause of injuries among firefighters in the observed period (37.8%), and injuries related to rescue and fire-fighting activities constitute 28.5%. Other work activities of firefighters cause 33.7% of injuries. In 2020 was a clear reduction in the number of accidents per 1000 employed firefighters in each observed parameter (total, interventions, sport) while maintaining the average level of firefighter employment ($M \pm SD$ 30 099 \pm 224). **Conclusions:** The most frequent circumstances of injury are slippery and challenging spaces, surfaces, and carelessness. The most common type of body injury is a dislocation and sprain concerning the ankle joint, foot. The most frequent causes of work-related injuries for firefighters, as the results indicate, are participation in team sports and fire-fighting and rescue operations. The most commonly occurring medical consequences resulting from a firefighter's injury are fractures, sprains, and contusions of various body areas. Firefighters are most burdened with injuries in the age group 26–35 years old. *Med Pr Work Health Saf.* 2023;74(6):469–77.

Key words: accidents, injuries, interventions, health hazards, state fire service, fire and rescue operations

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INTRODUCTION

The profession of a firefighter is fraught with a significant risk of injuries. Firefighters operate in hazardous zones to mitigate threats and combat fires. They evacuate endangered individuals directly from these zones where other rescue services cannot operate due to the lack of protective equipment procedures and appropriate training. Firefighting is a perilous profession, closely associated with a high risk of falling and is a critical element of people's safety [1].

The firefighter's work environment is characterized by many hazardous factors, among which we can distinguish: an adverse microclimate with extreme temperatures, air

pollution, excessive noise, physical strains, stress as a consequence of traumatic past events, and stress linked with the awareness of previous health threats. Firefighting service is laden with factors causing occupational diseases and also leading to bodily injuries during work-related accidents [2,3].

Firefighters conduct rescue activities for endangered individuals, animals, property, and the environment, mainly during interventions related to fire extinguishing, dealing with natural disasters, and actions within a specialized rescue group (SRG). A significant part of the fire and rescue units (FRU) undertake interventions in events typical for all units attributed to the firefighting profession, as well as specialized ones. In the Polish State Fire

Service (SFS), there are groups with various rescue specializations: technical, underwater, high-altitude, search and rescue, and chemical-ecological rescue. These groups operate on a permanent basis. Since 2021, specialized medical rescue groups (SRGMed) have been operating in the SFS, formed *ad hoc* in the province from officers with medical education who are currently on duty. The training and equipment of Polish SRGs are used during international operations. Polish firefighters have conducted rescue operations in various places around the world in previous years: in Lebanon, Nepal, Beirut, and in 2023 operations after the earthquakes in Turkey in March [4–8].

The vast array of responsibilities in a firefighter's routine makes it a profession prone to causing injuries among officers. Conducting fire and rescue operations on public roads during road collisions, railway and aviation disasters, on water bodies and underwater, carrying out rescue operations during building disasters, evacuating victims from excavations, wells, caves, and caverns, and animal evacuations are just some examples of interventions during which there's a risk of firefighter injuries. Firefighters, apart from interventions, have numerous duties to keep their equipment fully operational: personal equipment maintenance, addressing minor equipment malfunctions due to operation in harsh conditions, and maintaining the cleanliness of vehicles and rescue equipment [9–11].

Aim

Evaluate the accident rate of the officers of the Polish State Fire Service in connection with their service, considering direct participation in rescue operations, and other official duties between the years 2015–2022.

MATERIAL AND METHODS

Design

An 8-year analysis included data sourced from the Personnel Bureau of the Main Command of the SFS, the Department for Safety, Occupational Health, and Health Prevention. Data, gathered from all over Poland, came in the form of an annual analysis of the accident rate. Reports covered the number of accidents, the number of injured firefighters, the age of the officers, the circumstances of the event, and the type and location of the injury. The data considered a categorization of events into individual and collective accidents.

Setting

Firefighters' injuries incurred during duties related to their service were considered. This includes fire and

rescue operations, exercises, training, official trips, sports activities, and technical work related to equipment. Observations focused on the SFS population mainly serving in the FRU, as well as other entities forming the SFS structure in Poland, such as: provincial, city, and district commands, fire schools, the Scientific Research Center for Fire Protection in Józefów, and the Central Firefighting Museum in Mysłowice, Poland [12].

Ethical considerations

The data regarding the accident rate and described cases are fully anonymous. The analysis complies with the principles of the Helsinki Declaration and did not require the approval of an ethics committee. In December 2021, permission was obtained to access official data and use it for scientific purposes.

Inclusion criteria

Inclusion criteria were as follows:

- State Fire Service officers, both serving in the combat division (24-hour service) and office officers (8-hour service).
- Accidents recorded in the SFS accident rate registry during the period January 1, 2015–December 31, 2022.

Exclusion criteria

The analysis excluded data related to the health risks of civilian employees of Fire Protection Units, workers on periodic assignment for SFS, and volunteers from the Volunteer Fire Brigade (VFB).

Statistical analysis

The database was prepared in Microsoft Excel using the MS Office 2016 package for Windows 10. Descriptive statistics were used to characterize the variables. For quantitative variables, the following measures were calculated: mean (M) and standard deviation (SD). For categorical variables, the following measures were calculated: number (n) and frequency (%).

Limitations

Firefighters face not only physical hazards during service but also psychological burdens and diseases related to their profession. Access to data on the accident rate in SFS allowed for analysis of only injuries and did not classify other health risks resulting from exposure to harmful factors or stress and their consequences on the firefighter. The scale of other health problems, psychological burdens, consequences, and the monitoring of subjective firefighter perceptions about stress related

to service is a significant issue and could be the focus of further analyses. Literature on the health threats of firefighters includes studies on the psychological realm, stress including post-traumatic stress disorder (PTSD), sleep disorders, behavioral disorders, and diseases (including cancer) [13–18].

RESULTS

Between 2015 and 2022, there were 12 588 individual and group accidents in various circumstances. Most firefighter accidents occurred during rescue and fire-fighting operations, as well as during sports activities, as shown in Table 1.

As indicated by the data in Table 1, sports injuries dominate as the cause of injuries among firefighters in the observed period (37.8%), and injuries related to rescue and fire-fighting activities constitute 28.5%. Other work activities of firefighters cause 33.7% of injuries. This group includes exercises, training, inspections commuting to work, maintenance and repair of equipment, cleaning work in unit facilities.

Figure 1 shows the number of accidents per 1000 employed firefighters in subsequent years of the analysis, regardless of the cause and circumstances. The graphical record helps identify trends throughout the analysis.

In 2020 was a clear reduction in the number of accidents per 1000 employed firefighters in each observed parameter (Figure 1) while maintaining the average level of firefighter employment ($M \pm SD$ 30 099 \pm 224), and an

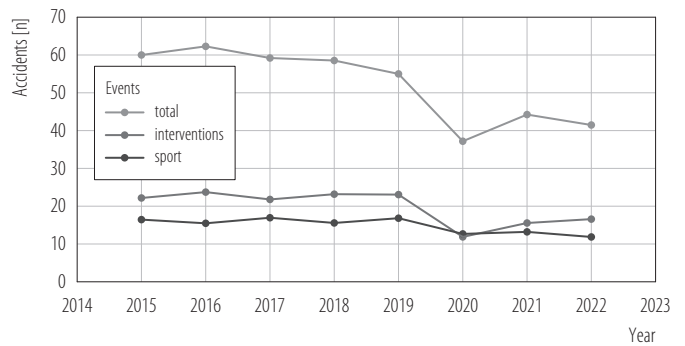


Figure 1. Accident rate per 1000 firefighters in subsequent years of the analysis (2015–2022)

increase in the number of interventions by 70.7 thousand between 2019 and 2020.

The circumstances and direct causes in which firefighters suffered injuries are presented in Table 2 and 3.

The type of injury and the area of the body that was injured are presented in Table 4. Bone injuries and contusions predominate, which corresponds to the data in Table 2. Bone injuries are characteristic of slippery, uneven surfaces if care is not taken.

In Figure 2 graphically presents data on the age of the injured, grouped into 10-year periods, and 2 limit values. Firefighters most at risk of injury are in the 26–35 age group.

In the years covered by the observation, 12 764 firefighters suffered injuries in individual ($N = 12 504$) and collective ($N = 84$) events. In collective accidents 260 firefighters were injured ($M = 3.1$ per incident).

Table 1. General characteristics of injuries among State Fire Service (SFS) officers between 2015–2022

Year	Participants' employment status [n]	All interventions (in thousands) [n] (N = 4242.1)	Accidents [n] (N = 12 588)		Interventions* [n (%)] (N = 3591, 28.5%)	Sports [n (%)] (N = 4762, 37.8%)	
			total	individual (N = 12 504)			group (N = 84)
2015	29 997	489.8	1801	1781	20	500 (27.7)	664 (36.8)
2016	29 851	446.8	1859	1848	11	460 (24.7)	708 (38.0)
2017	29 792	519.9	1767	1754	13	507 (28.6)	648 (36.6)
2018	30 240	502.0	1783	1773	10	476 (28.3)	705 (39.5)
2019	30 351	512.5	1678	1668	10	512 (30.5)	700 (41.7)
2020	29 969	583.2	1122	1113	9	376 (33.5)	357 (31.8)
2021	30 249	579.7	1312	1305	7	396 (30.1)	472 (35.9)
2022	30 349	608.2	1266	1262	4	364 (28.7)	508 (40.1)
M \pm SD	30 099 \pm 224.0	530.2 \pm 54.9	1573.5 \pm 290.8	1563.2 \pm 287.8	10.5 \pm 4.6	448.8 \pm 61.1	595.2 \pm 132.4

* Components of the intervention: alarm, travel to event, actual part of the intervention – rescue and firefighting actions, return to the station.

Table 2. Circumstances of injuries and health risks to firefighters between 2015–2022

Variable	Injuries and health risks circumstances [n]									
	2015	2016	2017	2018	2019	2020	2021	2022	total	M±SD
Related to structures: defect in workmanship, failure	18	24	15	12	23	7	17	7	123	15.3±6.4
Improper use of a material factor	17	12	7	24	15	7	19	16	117	14.6±5.7
Difficult, uneven, slippery spaces, ground	372	400	389	431	360	252	258	255	2717	339.6±68.5
Lack, improper selection or ineffective protective measures	10	14	10	12	13	6	9	7	81	10.1±2.6
Improper organization of work	3	7	2	5	5	1	5	5	33	4.1±1.8
Failure to comply with regulations and rules Occupational Health and Safety	25	19	27	13	20	10	21	10	145	18.1±6.2
Improper psychophysical condition	2	4	0	5	14	9	3	5	42	5.2±4.2
Incorrect behavior, carelessness	1006	1013	929	1060	1002	608	689	672	6979	872.3±176.6
Other	324	335	362	181	174	79	234	238	1927	240.8±90.1

Table 3. Direct causes of injuries and health risks to firefighters between 2015–2022

Variable	Injuries and health risks direct causes [n]									
	2015	2016	2017	2018	2019	2020	2021	2022	total	M±SD
Hitting, crushing by a falling, spilling or pouring material factor	71	64	68	65	61	56	50	52	487	60.8±7.5
Contacting or hitting stationary material factors	176	216	196	198	163	97	134	132	1312	164±40.4
Contacting, hitting, catching or crushing by moving material factors	177	168	165	184	173	96	126	118	1207	150.8±32.6
Tripping, slipping, losing balance, falling, including from a height into depressions	852	856	797	778	683	474	545	520	5505	688.1±155.6
Traffic accident	50	39	47	39	38	36	35	26	310	38.7±7.3
Extreme temperatures, troublesome weather conditions	20	27	25	21	23	11	11	12	150	18.7±6.5
Explosion	0	3	1	3	3	1	0	2	13	1.6±1.3
Contact with chemical, infectious substances, radiation and others	16	11	7	19	27	6	11	11	108	13.5±6.9
Physical dynamic load	313	332	323	387	409	239	308	314	2625	328.1±51.8
Other (animals, forces of nature)	150	162	162	109	101	106	92	80	962	120.2±32.7

Collective accidents mainly include injuries in team sports (contact) and traffic accidents.

DISCUSSION

Service in the SFS is associated with high occupational risk. Firefighters in their profession are exposed to significant physical and psychological stress. The number of firefighter interventions increases each year, but the number of accidents does not (Table 1). This might suggest better personal protection for firefighters, train-

ing levels, and risk awareness during operations in the firefighters' own assessment.

Krzemińska et al. studied the level of firefighters' individual protection. They evaluated harmful factors in the firefighter's working environment, including air pollution, the presence of combustion products, and chemicals that can be toxic, corrosive, flammable, explosive, or allergenic. Firefighters' awareness of these threats is high, and they are also equipped with individual protective measures: special clothing, special gloves, balaclava, firefighting boots, and a firefighting helmet. Special

Table 4. Clinical consequences of firefighters’ health risks between 2015–2022

Variable	Injuries and health risks [n]									M±SD
	2015	2016	2017	2018	2019	2020	2021	2022	total	
Loss of limbs or parts thereof	0	0	0	1	3	0	0	1	5	0.6±1.0
Fractures, bone cracks, dislocations	987	992	882	973	1024	572	706	661	6797	849.6±176.9
Bruises	312	307	352	331	236	160	163	148	2009	251.1±84.7
Wounds	179	186	198	221	155	111	127	127	1304	163.0±39.1
Burns	34	37	25	27	28	20	25	23	219	27.3±5.6
Frostbite	0	1	0	0	0	120	175	189	485	60.6±85.6
Internal injuries	47	44	39	59	60	16	11	14	290	36.2±20.0
Eye damage	13	9	16	16	13	19	18	20	124	15.5±3.6
Electric shock	0	5	1	2	0	12	13	21	54	6.7±7.7
Other (affecting the circulatory, nervous, digestive systems)	296	321	310	191	198	120	101	86	1623	202.8±96.4

clothing, protecting the firefighter’s limbs and torso, plays a crucial role [19]. These body areas, according to the authors’ analysis (Table 4), may be highly prone to injury.

Bajor et al. point to psychosocial causes of health threats for firefighters: haste, routine, fatigue, or occupational burnout, which influence the emergence of dangerous situations and reduce the level of work safety. The data in authors’ results in Table 2 may partially confirm these observations, with particular attention to injury circumstances in columns: improper psychophysical condition, as well as improper behavior and carelessness [20].

Grzybowski et al. analyzed the causes of firefighters’ injuries during the period 2010–2016. The authors indicate that among the main reasons for firefighters’

injuries are improper behavior and inadequate job-specific and professional training in OHS. These findings, regarding the causes of accidents, correspond with the results of the authors’ analysis [21].

Pawlak et al. conducted an analysis methodologically similar to authors’ observations but based on data from a decade earlier. During this time, the spectrum of threats changed, the number of firefighter interventions increased, and protective measures evolved. The health threats to officers had causes similar to authors’ observations, are still relevant. The most accident-prone group is firefighters from FRU. The most accidents were caused by sports activities, including bone fractures and dislocations [22].

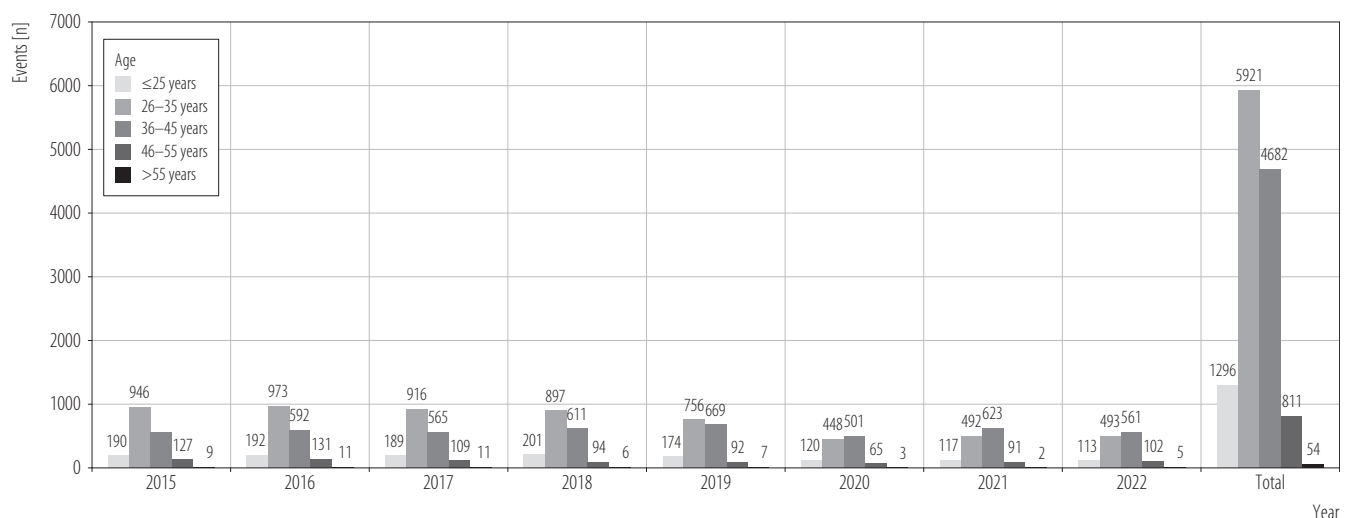


Figure 2. Injured officers by age in 2015–2022

Młynarczyk highlights an intriguing potential cause of some firefighter accidents in observations concerning special (protective) firefighter clothing. Optimal working conditions for a firefighter in adverse circumstances would be created by so-called thermal comfort, characterized by a thermo-neutral state of the body. The lack of feeling thermal comfort may also be a reason for the increased number of mistakes made. The errors pointed out by the author fit into the improper behavior and carelessness discussed in the authors' analysis [23].

Confirmation regarding the impact of firefighter clothing on the safety of operations can be found in the observation by Dąbrowska et al. The challenging environmental conditions during firefighting operations necessitate efforts to develop a new type of intelligent protective clothing, equipped with systems facilitating communication and providing comprehensive data about the firefighter's health. It is crucial that the clothing meets safety standards but also fulfills the firefighters' expectations. Present analysis did not directly address the aspect of clothing and its protection during a firefighter accident. Scientific analyses of firefighter clothing mainly concern clothes dedicated to rescue and firefighting activities. According to authors' analysis, many accidents relate to sports activities and repair and maintenance of equipment. During these activities, firefighters do not wear special clothing [24].

Heynes analyzed the injuries of American firefighters, with special emphasis on injuries resulting from a fire defined as the initial circumstance leading to injuries. Accidents during firefighting since 1981, when data on firefighter injuries were first collected, have been on a declining trend. In this analysis, the data from Table 1 indicate a significant share of firefighting activities in the accident rate of firefighters. One must consider the high dynamics of firefighting actions, limited visibility, the need for demolition work during a fire, instability of structures, and the risk of explosions [25].

Goncaryk points to possible causes of injuries during official duties in medical rescue. Firefighters from FRU have an interventionist nature of work, often under time pressure, with the need to carry heavy loads (victims and equipment). It can be inferred that the musculoskeletal injuries of firefighters have a similar etiology as medical services during interventions: carrying over uneven surfaces, stairs, in challenging terrain conditions, often with improper working posture due to fatigue [26].

The injury rates among medics are confirmed by Kłosiewicz's survey study. There are many risk factors

contributing to the hazards of work for medical rescuers and nurses of Medical Rescue Teams. Firefighters, who often carry out medical actions jointly with National Medical Rescue Units, or independently when they arrive first at the scene, fit into this mechanism [27].

Analysis could not overlook the aspect of sports as a cause of firefighter injuries. Sports and proper physical condition are vital in this profession. A firefighter, upon joining the service, is verified in terms of physical fitness [28].

Later in the service, sports also play a significant role. However, it leads to numerous injuries. As indicated by the 2023 analysis of Polish firefighters, team sports and the most crucial injury factor – contact, cause the most injuries. Team disciplines such as soccer, volleyball, and basketball are contact sports with high dynamics, generating numerous injuries [29].

Different methods of training and maintaining physical fitness by firefighters are recommended to improve the results of fitness and endurance tests, which translates into efficiency during real rescue operations. Scientific evidence suggests that systematic exercise increases physical fitness, thereby reducing the number of injuries sustained during rescue operations among firefighters [30,31].

The literature on the subject regarding foreign research confirms that firefighter service generates many health risks and injuries. Hyung Doo et al. analyzed work-related injuries of Korean firefighters in 2010–2015. The analysis included 2154 events, the most common causes of which were loss of motor balance (30.3%), falls (18.9%) and traffic accidents (13.4%). The main exposed body areas are the back (25.3%), and the mechanism of injury is sprains and contusions (27.2%). Analogously to their own analysis, the Korean authors calculated the accident rate per 1000 firefighters at 9.8 [32].

Ghiyasi et al drew attention to the effect of thermal stress in the practice of firefighters and the impact of this factor on work efficiency and increased occupational accident rates. The aim of the study was to assess the impact of personal protective equipment on thermal stress. Authors' study did not assess high temperature in the firefighter's work environment as a factor that impedes functioning. Taking into account firefighting activities, it can be agreed that physical effort combined with increased temperature generates thermal stress and predisposes to fatigue, lack of caution and indirectly affects accidents [33].

Similar results can be found in the work of Orr, whose aim was to review the literature on musculo-

skeletal injuries occurring during firefighting. Popular mechanisms of firefighter injuries include sprains and strains caused by slips, trips and falls, but also lifting, crouching and muscle strain [34].

In a study on French firefighters, the authors looked for physiological and psychological risk factors for ankle sprains. The authors took into account previous injuries to this area among firefighters, anthropometric results, body posture tests, and asymmetries. This type of injury was quite common in present analysis [35].

Kaipust assessed the effects of obesity and sleep on on-duty injuries among professional male firefighters. The study conclusions were interesting: obese firefighters who did not get enough sleep were twice as likely to be injured while on duty [36].

Wiśniewski addressed the issue of obesity among Polish firefighters in the 19–53 age group. However, the study did not analyze the impact of body mass index (BMI) on the likelihood of injury. The study noted that body weight assessment is useful for working on new personal protective equipment for rescuers and for properly assessing their fitness and physical capacity. The databases used for authors' analysis did not contain anthropometric information of officers who were injured during service, but it can be concluded that obesity does not have a positive impact on the requirements awaiting firefighters during rescue and fire-fighting operations [37].

CONCLUSIONS

The obtained results indicate that injuries in the firefighter profession are inevitable, hence it is advised to implement preventive measures to minimize this risk. The most frequent circumstances of injury are slippery and challenging spaces, surfaces, and carelessness. The most common type of body injury is a dislocation and sprain concerning the ankle joint, foot. The most frequent causes of work-related injuries for firefighters, as the results indicate, are participation in team sports and fire-fighting and rescue operations. The most commonly occurring medical consequences resulting from a firefighter's injury are fractures, sprains, and contusions of various body areas. Firefighters are most burdened with injuries in the age group 26–35 years old. A significant proportion of accidents are related to activities other than firefighters' interventions, which draws attention to the need to follow occupational health and safety rules not only during rescue and fire-fighting operations.

Author contributions

Research concept: Łukasz Dudziński

Research methodology: Łukasz Dudziński, Tomasz Kubiak

Collecting material: Łukasz Dudziński, Tomasz Kubiak, Tomasz Milczarczyk

Statistical analysis: Łukasz Dudziński, Łukasz Czyżewski

Interpretation of results: Łukasz Dudziński, Łukasz Czyżewski

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