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Multiple Fatal Accidents at Work in Italy: How They Occur and Causal Factors for Identifying Specific Prevention Measures

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Abstract

Background: *Workplace accidents represent a significant health problem for workers. In 2022, the EU recorded over 3,000 workplace deaths and nearly 3 million non-fatal accidents. The aim of this paper is to provide an in-depth analysis of multiple fatal accidents in Italy in recent years, analyzing their occurrence patterns and causal factors to increase useful information for risk management.* **Methods:** *The statistics come from the INAIL Database and the Infor.MO National Surveillance System, which collects detailed information on accident dynamics and uses a multifactorial model to analyze the causes of injuries. In this system, the in-depth analysis of multiple fatal accidents was conducted on a cluster of 181 events that occurred between 2008 and 2022.* **Results:** *Data sources show that road accidents are a significant cause of multiple injuries. Other recurring accidents include collapses, fires, explosions, and asphyxiation in confined spaces. The construction and manufacturing sectors are the most affected. The main causes, highlighted particularly in the Infor.MO system, include poor worker training, inadequate workplace organization, and a lack of safety devices.* **Conclusions:** *To reduce workplace accidents, especially those with dramatic consequences such as multiple accidents, the importance of a stronger organizational safety culture is reiterated, in which training enables workers to understand risk analysis and gain greater awareness of hazards.*

1. Introduction

Workplace accidents continue to represent a significant issue for the health conditions of working populations [1, 2]. According to Eurostat, which bases European statistics on work-related accidents on the ESAW classification system [3], in 2022 in the EU there were over 3 thousand work-related deaths and almost 3 million non-fatal accidents, with a ratio of approximately 905 non-fatal accidents for every fatal accident.

For Italy, more recent data are provided by the National Institute for Insurance against Accidents at Work (INAIL) through reports and public online databases. In 2023, 550 fatal accidents were recognized at work [4]. INAIL data report each year the share of multiple fatal accidents, which occurred both at work and *in itinere*, i.e. on the way to and from work. The balance of recent years shows that in the decade 2015-2024, 160 multiple fatal accidents occurred, for a total of 429 victims with an average of almost 3 deaths per event. Furthermore, over the ten-year period, fatalities associated with multiple-casualty events constituted more than 3% of all occupational deaths [5].

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Nine out of ten workers who sustain fatal injuries die in an accident in which they are the only fatality. For the remaining 10% of worker deaths, the fatal accident resulted in the death of more than one worker. These accidents are of particular interest to safety professionals and risk researchers because preventing each of these accidents results in the saving of more lives [6].

Multiple fatal accidents are often associated with activities and processes that by their very nature are high risk and can put several workers at risk at the same time. Examples of this include establishments that use hazardous substances, for which there are regulations on aspects related to the prevention of major accident risks [7, 8], and the operational procedures carried out in confined-space working environments [9].

The most common types or situations associated with multiple fatal workplace accidents were road traffic accidents, coal mine explosions, and accidents involving maritime transport (3,978 fatalities) [10]. In relation to the construction sector, a case study of the sector in England highlighted that the situation is such that a catastrophic event can represent a plausible scenario, with the potential for multiple casualties and serious consequences [11].

Despite their significance, the prevalence of accidents resulting in multiple work-related fatalities is not well documented. Multi-fatal accidents occur mainly in few circumstances. The main situations involve transportation accidents, fires and explosions, and violence [12].

The aim of this paper is to present an analysis of multiple fatal accidents that have occurred in Italy in recent years, examining their occurrence patterns and causal factors in order to increase the information useful for risk management.

2. Methods

The data illustrated refer first of all to the statistics published by INAIL in its Annual Reports and in its periodic publication "Dati Inail". For these sources, multiple fatal accidents are defined as tragic events where two or more workers lose their lives at the same time [13].

Based on this information, the most striking events that have occurred from January 2007 to December 2024 have been identified and the ways in which they occurred have been highlighted.

Within the INAIL database, statistical data originates primarily from local offices. These collect administrative data on accident reports, which are then validated and entered into the Institute's central archive. From this data, statistics are compiled on reported, defined (for which the investigation into the report has been concluded with a positive or negative recognition), and compensated (accidents positively recognized and for which the worker is entitled to compensation).

In order to highlight the causal factors that determined the modalities of multiple accidents, we used the archive of the national surveillance system for fatal and serious accidents Infor.MO [14]. This information source provides detailed data on the dynamics of accident events, allowing for the expansion and integration of available data on reports and compensation of the INAIL insurance databases.

For the analysis of multiple fatal accidents, a cluster of 181 events was considered within the Infor.MO system, with multiple workers injured simultaneously and at least one death recorded, occurring between the beginning of 2008 and the end of 2022 (the latest year with available data). These events were selected using a specific "collective event" variable present within the information system's record trace.

The Infor.MO system records information from accident investigations conducted by the Italian Workplace Prevention Services of Local Health and Safety Departments (LHSDs) on the most serious incidents. A multifactorial model, developed and validated by INAIL and the Italian Regions, is used to enter the data into the archive to identify the causes of the accident [15].

The system has gradually consolidated, moving from an original experimental phase (2002-2004) to a phase in which it was permanently adopted by the project promoters, who confirmed its organizational structure, objectives, and methodologies. It is listed in the Ministry of Health's National Prevention Plan (2020-2025) as one of the active surveillance systems useful for planning prevention, promotion, assistance, and monitoring interventions [16].

The multifactorial model is one of the causal tree models [17, 18, 19, 20] and allows for a structured evaluation of the event dynamics, starting from the elements that describe the injury event:

- The accident, or the unexpected event that 'supplies' dangerous and uncontrolled energy in the workplace (e.g., overturning of a work vehicle, explosion of materials being processed, etc.);
- Contact, determined between the injured body part and the environmental element involved (e.g., the leg trapped under an overturned tractor);
- Biological damage, defined by the nature and location of the injury (e.g., fracture of the tibia and fibula).

Furthermore, the model allows us to identify all the possible factors that contributed to the accident, classifying them as determinants or modulators and describing them in detail. The determinant is the factor that increases the probability of an accident occurring (for example, working on a roof without adequate protection increases the probability of a worker falling from a height). The modulator is the factor that, while not affecting the probability, contributes to increasing the severity of the injury (for example, failure to wear a safety helmet leads to greater consequences in the event of objects falling on the worker).

The factors identified as determinants or modulators can be divided into one of the following six categories:

- Activity developed by an injured person, inappropriate actions, movements, etc., carried out by an injured worker during the event;
- Activity developed by a third subject Incorrect actions developed by other workers or people (different from the injured one) during the event;
- Equipment, machine, plant, working tool Equipment of any type (or part of it) that presented criticalities in the dynamics of the event;
- Materials Issues on the processed materials that influenced the dynamics of the event
  Working environment conditions Critical aspects related to workplace conditions;
- Working environment conditions: critical aspects related to workplace conditions;
- Personal Protective Equipment and clothing issues that influenced the injury occurrence.

For each category, safety issues are identified, i.e., the critical issues that characterize the determinant and modulator within the accident dynamics. For example, with regard to Activities, the lack of training; and with regard to Equipment, the absence of machine protection systems.

3. Results

Among the multiple accidents, the most sensational cases, also from a media perspective, are reported below:

- 2007: 7 workers killed in fire at a Turin steelworks;
- 2008: 6 workers died while cleaning a sewage treatment plant tank in the province of Catania;
- 2009: 3 workers asphyxiated by toxic gases in Sardinia;
- 2013: 7 victims in fire at a textile factory in Prato;
- 2015: Two accidents in fireworks factories killed 4 workers in the Campania region and 10 workers near Bari;
- 2017: A landslide killed 29 people, including 11 hotel employees in a mountain resort; 6 deaths (including 5 crew members) in crash of an emergency helicopter;
- 2018: Over 30 deaths have resulted from two road accidents: the collapse of a major bridge in Genoa; a head-on collision between a truck and a farm workers' van In the Italian region of Puglia;
- 2022: 19 multiple deaths, 46 deaths total, 44 of which were due to road accidents;
- 2023: 5 workers hit by a train while performing railway track maintenance in Brandizzo, near Turin;
- 2024: 5 workers killed during sewer maintenance in Italian region of Sicily.

From this preliminary examination of the most significant events, several recurring patterns of multiple-fatality incidents can be identified, particularly those associated with fires and explosions, transport-related accidents, confined-space environments, and environmental catastrophes.

In more recent years, based on the available Inail data, a first observation regarding multiple accident data is that trends over time are strongly influenced by road accidents, often during commuting, which are covered by INAIL under workers' insurance regulations. For example, the peak of 82 fatalities observed in 2018 (Table 1), compared to an average of 35-40 multiple deaths annually, is due to two serious road accidents that year, which alone resulted in over 30 worker deaths.

Focusing on the most common causes of multiple fatal accidents, in INAIL data we observe:

- Accidents involving means of transport both at work and while commuting;
- Crushing injuries;
- Falls from heights;
- Fires, explosions;
- Suffocation, asphyxiation (often in confined spaces).

Further characteristics of multiple fatal accidents derive from the analysis of the cluster of events extracted from the Infor.MO surveillance system.

Of the 181 cases extracted from the Infor.MO archive for the years 2008-2022 (Table 2), two-thirds occurred in the Construction and Manufacturing sectors (Istat, Ateco[1] classification of economic activities). Focusing only on events that resulted in fatality, the percentage of cases for these two sectors drops to approximately 50%. Two other sectors where the incidence of multiple fatal accidents is significantly higher than that of fatal cases are Water Supply and Waste Management, and Electricity Distribution.

In the Infor.MO system, in the sectors with the highest incidence of multiple accidents, the most common types of accidents are collapses, landslides, explosions, and contact with gas in confined spaces. With the exception of road accidents, which are almost never directly investigated by the Local Health and Safety Departments (LHSDs) and therefore not recorded in Infor.MO, the same patterns of occurrence previously highlighted in the INAIL database are confirmed.

The causal factors of fatal accidents can be explored further using the Infor.MO database (Table 3). Comparing the cluster of multiple accidents with other accidents, a greater weight is observed for risk factors related to workplace layout, the activities of third parties in teamwork, the management of personal protective equipment, and the materials handled in production processes.

Going into greater detail about the safety issues that characterize multiple accidents compared to other accidents, the most common factors are, in decreasing order, a lack of worker training, information, and instruction, which is recurrent in the "teamwork" factor (14.4% for multiple accidents vs. 10.7% for other accidents). This is followed by inadequate signage, lack of ventilation, and unexpected presence of electricity or gas (12.3% vs. 5.6%), which characterize the "work environment" factor. The storage of gaseous and liquid materials and their characteristics constitute a more recurring safety issue among multiple fatal accidents (8.7% vs. 3.2%). The problem of a lack of training, information, and instruction also recurs in the use and management of PPE (2.4% vs. 0.8%). Finally, regarding work equipment, problems with multiple accidents are often related to poor maintenance (15.2% vs. 8.8%).

Table 1. Extract of the most recent multiple fatal accidents in Italy by INAIL databases in the period 2018-2024.

Year	N
2024	39
2023	36
2022	46
2021	40
2020	27
2019	44
2018	82

[1]Italian version of the European NACE classification, used to classify businesses by their economic activity for official statistics, fiscal, and administrative purposes.

Table 2. Distribution of multiple accidents by sector of activity.

Ateco Business Sector	% Multiple Accidents	% Other Injuries
Constructions	38.4	32.2
Manufacturing Activities	25.4	18.4
Agriculture, Forestry and Fishing	10.2	30.9
Transport and Warehousing	7.9	7.8
Water Supply; Sewerage, Waste Management and Remediation Activities	4.4	2.1
Supply of Electricity, Gas, Steam and Air Conditioning	3.5	0.8
Wholesale and Retail Trade; Repair of Motor Vehicles and Motorcycles	3.5	3.3
Other sectors	6.7	4.5

Table 3. Distribution of causal factors of multiple accidents by category.

Risk Factor Categories	% Multiple Accidents	% Other Injuries
Activity Developed by an Injured Person	25.5	47.4
Working Environment Conditions	21.6	13.9
Activity Developed by a Third Subject During the Event	17.6	8.8
Equipment, Machine, Plant, Working Tool	17.0	19.6
Personal Protective Equipment (PPE) and Clothing	10.7	7.5
Materials	7.6	2.8
Total	100.0	100.0

Workplaces characterized by confined spaces are recurrent for multiple accidents, both in INAIL data on reports and in data extracted from the Infor.MO system. The latter shows that the location where multiple fatal accidents occur in two-thirds of cases is represented by tanks, reservoirs, basins, and wells.

The main risk factors are once again improperly executed teamwork procedures, especially in emergency situations where workers die not because they were directly involved in the operational procedures but instinctively assisting the first injured person, and the environmental factor, due to the presence of gases and vapors not assessed prior to access and the lack of suitable worker recovery systems. Both the procedures and the rescue intervention, in multiple accidents, appear to have occurred without the use of adequate protective equipment (e.g., self-contained breathing apparatus, environmental monitoring).

4. Discussion

Analysis of data provided by INAIL (National Institute for Insurance against Accidents and Workers' Compensation) and the national surveillance system Infor.MO highlights several critical areas of occupational risk. A significant share of workplace accidents and multiple fatalities involve the use of transportation, both during work activities and during commuting, underscoring the importance of road-related risks in the overall burden of fatal workplace accidents.

Surveillance data reveals that multiple accidents frequently occur in operational settings characterized by moving equipment, inadequate safety measures, or insufficient organizational controls. Falls from heights are another significant risk factor, often associated with the absence or improper use of protective equipment and deficiencies in workplace safety management.

Although the studies available in the literature are not directly comparable due to differences in data extraction methods and the nature of the information collected, the evidence is consistent in focusing on the critical areas identified in this review.

One study [9] examined operational procedures implemented in confined work environments, contributory factors that have been frequently identified following enclosed space accident investigations are non-compliance with procedures, inappropriate equipment, poor supervision, complacency and over familiarity leading to short cuts being taken, detection and monitoring equipment not used or not working properly and improper action in an emergency.

The literature indicates that the most common circumstances associated with multiple fatal workplace accidents include road traffic accidents, coal mine explosions, and accidents involving shipping, which together resulted in 3,978 fatalities [10].

In the construction sector, a case study conducted in England highlighted that the occurrence of a catastrophic event represents a plausible scenario, given the nature of the work processes and the potential for multiple fatalities and serious consequences [11].

Despite their relevance, the prevalence of multiple fatal workplace accidents remains insufficiently documented, with such events typically occurring under a limited set of conditions, most often involving transport accidents, fires and explosions, and acts of violence [12].

The safety issues most frequently identified in the Infor.MO system for multiple fatal accidents draw attention to organizational factors, particularly the need for adequate training for workers and for the organization of work areas, not to mention appropriate training for complex work activities and the correct use of protective equipment.

These aspects were also highlighted in the recent report produced by the Parliamentary Commission of Inquiry into working conditions in Italy, exploitation and the protection of health and safety in public and private workplaces [21] established in 2023. The report, approved in September 2024, concerned the work carried out by the Commission in relation to the railway accident which occurred in Brandizzo in the province of Turin in 2023, where 5 workers died during maintenance of the railway tracks.

Among the points highlighted by the Commission, as fundamental recommendations to ensure adequate health and safety conditions for workers, the following passages from the report are reported:

- Periodic assessment of personnel skills to detect any deviations through actual observation of worker behavior (supervision by company supervisors);
- Training activities aimed at enabling workers to conduct their own risk assessments to become aware of the inherent dangers of their activities;
- Verification of processes in the field through structured audits and effective management of identified non-conformities to monitor risks, including organizational and interference-related risks;
- Contracts/subcontracting: Improvement of contract awarding processes that give adequate importance to worker health and safety by amending the rules governing procurement;
- Promotion of participation and whistleblowing processes, such as reporting near misses and OSH issues.

Regarding the last point, it should be noted that the accident resulted, in addition to the multiple fatal injuries of five workers, in two near misses. Indeed, the worksite consisted of seven people, all exposed, albeit in different ways, to the risk of being hit by the passing train due to the railway line not being interrupted.

From a prevention perspective, it is essential to increase knowledge not only about the occurrence and causes of accidents, but also about near misses that occur in the workplace without causing harm to workers. Near misses effectively represent sentinel events that must be addressed during the risk assessment review phase before workers suffer the consequences. A key element in detecting and monitoring such events is the communication process between all parties in the company supply chain.

Worker characteristics, particularly age, can interact with the type of contract and the organizational fragmentation typical of contract work, influencing

the level of occupational health and safety protection. All these factors constitute a complex system that must be taken into account when analyzing accident dynamics [22].

The report, as stated by the Commission, represents a starting point for an in-depth examination of multiple fatal accidents that can lead to "comprehensive legislative proposals to be submitted to Parliament, which embody the essence of best practices in workplace safety".

Therefore, the Commission's recommendations become particularly significant when compared with the data obtained from the current study, which highlights critical shortcomings related to the risk assessment process, such as insufficient company controls and inadequate worker information and training.

These findings underscore the need to strengthen worker safety, including through the role of health surveillance and occupational physicians, ensuring the constant updating of preventive practices.

In contexts characterized by a lack of awareness of social responsibility and work ethics, some measures, such as continuous monitoring of risk conditions in the workplace, require constant attention to the surveillance of risk factors, particularly those of an organizational nature.

5. Conclusions

The analysis of workplace accidents with multiple fatalities highlights organizational risk factors and those related to operational interference, which are more significant than those that cause single fatalities.

The most common safety deficiencies observed in workplace accidents with multiple fatalities include inadequate information and training systems for workers, poor workplace organization, and the absence or inadequacy of safety devices.

As noted by the Parliamentary Commission of Inquiry into Working Conditions in Italy, internal company processes play a fundamental role in controlling risk factors, starting with the identification of near misses that often lead to serious or fatal injuries, including multiple injuries. Continuous data collection on workplace risk conditions is essential for proper occupational health and safety management.

Ultimately, reducing workplace accidents requires strengthening the organizational safety culture and a more participatory relationship between workers and the company, starting with the involvement and constant dialogue between all legally required stakeholders of the company's prevention system.

Identifying workplace prevention measures is also facilitated by greater cooperation between the relevant institutional bodies and social partners. Specifically, this involves implementing a nationwide monitoring system for in-depth causal analysis of accidents and near misses, timely and coordinated emergency response management, and verifying the effectiveness of preventive measures.

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