Disaster Medicine and Public Health Preparedness

www.cambridge.org/dmp

Research Letters

Cite this article: Altintas E, Ataman AK and Ongar M (2024). Characteristics of Technological Disasters. *Disaster Medicine and Public Health Preparedness*, **18**, e197, 1–9
https://doi.org/10.1017/dmp.2024.167

Received: 09 March 2023
Revised: 09 February 2024
Accepted: 04 August 2024

Keywords:
technological disaster; global; transport accident; industrial accident; miscellaneous accident

Corresponding author:
Emel Altintas;
Email: emelaltintas61@gmail.com

Characteristics of Technological Disasters

Emel Altintas[1], Ali Kaan Ataman[2] and Murat Ongar[3]

[1]Ufuk University, Department of Emergency Medicine, Ankara, Turkey; [2]Izmir Tepecik Training and Research Hospital, Konak, İzmir, Turkey and [3]Ankara Training and Research Hospital, Ankara, Ankara, Turkey

Abstract

Objective: Disasters are the consequences of natural or technological hazards that affect a vulnerable society.[1] Technological disasters are divided into three groups: industrial, transport, and miscellaneous.[2,3] It is possible to determine the risks of technological disasters, to determine priorities, and to plan services by knowing this epidemiology.[4] In this study, we aimed to define the distribution and characteristics of the subtypes of technological disasters in the world according to regions and years.

Methods: Our study was conducted using the international dataset at www.emdat.be/. The technological disasters between 1970 and 2020, the years they occurred, their locations (region and continent), the types of disasters, and the numbers of dead and affected were recorded.

Results: We found that the greatest number of disasters occurred between 2001 and 2010. The most common type of disaster was transportation accidents. While the continent with the most frequent disasters was Asia (3 879 [45.6%]), it was followed by Africa (2 220 [26.1%]) and South and North America (1 359 [16%]).

Conclusions: Transport accidents are the most common cause of technological disasters, and road accidents are the most common type of transport accident.

Disasters are the consequences of natural or technological hazards that affect a vulnerable society.[1] A technological disaster is declared when a technological danger causes the death of 10 or more people, impacts 100 or more people, or leads to the declaration of a state of emergency or an international call for help.[2,3]

The EM-DAT database is not widely used by disaster medicine in general. The EM-DAT database classifies technological disasters into groups: industrial, transport, and miscellaneous. Industrial disasters are hazards caused by any product or substance that is directly or indirectly associated with an industrial or manufacturing process, including human activities. Examples include industrial pollution, toxic waste, chemical spills, and nuclear radiation. Transportation disasters are situations caused by a transport accident or related vehicles, infrastructures, or hazardous materials, including human errors. Examples include aircraft crashes, vehicle collisions, and bridge collapses. Miscellaneous disasters are situations caused by structural failures, fires, or explosions directly or indirectly related to human errors. Examples include dam collapses, plant fires, and equipment failures.[4]

Since the Industrial Revolution, disasters resulting from technological hazards have increased. As the global population surges, urbanization continues to spread, and industrialization intensifies, this increase is likely to continue.[4] It has been reported that obtaining information about disasters and preparing for them is the most effective way to prevent disasters or reduce their effects.[3] It is possible to determine the risks of technological disasters, to determine priorities, and to plan services by knowing this epidemiology. Therefore, in this study, we aimed to define the distribution and characteristics of the subtypes of technological disasters in the world according to regions and years.

Method

Our study was conducted using the international dataset at www.emdat.be/. The technological disasters between 1970 and 2020, the years they occurred, their locations (region and continent), the types of disasters, and the numbers of dead and affected were recorded.

In summarizing the data obtained for the study, descriptive statistics were tabulated as medians, minimums, and maximums depending on the distributions for continuous (numerical) variables. Categorical variables were summarized as numbers and percentages. The normality status of each numerical variable was checked using the Shapiro–Wilk, Kolmogorov–Smirnov, and Anderson-Darling tests.

A Pearson chi-square test was used to compare the differences between the categorical variables according to the groups in the 2 × 2 tables, where the expected cells were 5 and above,

Fisher's exact test was used for the tables when the expected cells were below 5, and the Fisher–Freeman–Halton test was used for the R × C tables when the expected cells were below 5.

Statistical analyses were performed using the Jamovi (version 2.2.5.0) and JASP (version 0.16.1) programs, and the significance level was set at 0.05 (*P* value) in the statistical analyses.

Results

When the last 50 years of the international disaster database were examined, we found that the greatest number of disasters occurred between 2001 and 2010 (3 051 disasters and 35.9%). The most common type of disaster observed in the last 50 years was transportation accidents (5 666 disasters and 66.6%) and there has been a significant increase over more than ten years. In industrial accidents, explosions took the first place, followed by fires and collapses (920 [32.3%], 875 [30.8%], and 438 [15.4%], respectively). In the "miscellaneous disasters" category, explosions, fires, and collapses also take the first three places (920 [35.5%], 875 [33.8%], and 438 [16.9%], respectively). While the continent with the most frequent disasters in the last 50 years was Asia (3 879 [45.6%]), it was followed by Africa (2 220 [26.1%]) and South and North America (1 359 [16%]) (Table 1).

According to the records of the international disaster database, miscellaneous accidents were observed significantly more frequently than industrial and transport accidents from 1970 to 1980, while industrial accidents were also observed significantly more frequently than transport accidents (miscellaneous accidents > industrial accidents > transport accidents). Disaster types were observed at similar frequencies in 1981–1990 and 1991–2000. In 2001–2010, industrial and transport accidents were observed at similar frequencies and at significantly higher frequencies than miscellaneous accidents (transport accidents = industrial accidents > miscellaneous accidents). Finally, in 2011–2020, transport accidents and miscellaneous accidents were observed at similar frequencies and at significantly higher frequencies than industrial accidents (transport accidents = miscellaneous accidents > industrial accidents) (Table 2).

It was observed that the frequency of transport accidents from 1970–1980 was significantly lower than the frequency of transport accidents observed in all other decades, while the frequency of miscellaneous accidents was significantly higher from 1970–1980 than in all other decades. When industrial accidents were examined, it was observed that the accidents from 1970–1980 were more frequent than the accidents observed in all other decades (Table 3).

In the last 50 years, fire was the most common disaster among industrial accidents from 1970–1980 and 1981–1990, while explosions were the most common industrial accidents from 1991–2000 and 2001–2010. From 2011–2020, fire was again the most frequently observed industrial accident. A similar situation was observed in the subtypes of "miscellaneous accidents." When transport accidents were examined, train accidents from 1970–1980 and road accidents in the following years were the most common transport accidents (Table 4).

Transport accidents observed in Africa were significantly more common than those observed on the other continents. In terms of industrial accidents, similar accident rates were observed in Europe, South and North America, and Oceania, and accident rates in Asia were significantly higher than in Europe, South and North America, and Africa (Table 5).

Fires in Europe, South and North America, and Oceania, explosions in Asia, and collapses in Africa were the most common industrial and miscellaneous accidents. When transport accidents were examined according to region, airway accidents were the most common accident subtype in Europe and Oceania, while road accidents were the most common accident subtype in Asia, South and North America, and Africa (Table 6).

Discussion

In this study, we determined that the most common type of disaster was transportation accidents and that disasters were most common on the Asian continent. In the 1970s–1980s, transportation accidents were found to be less common than in other decades, while miscellaneous and industrial accidents were found to be more common. Industrial accidents and miscellaneous

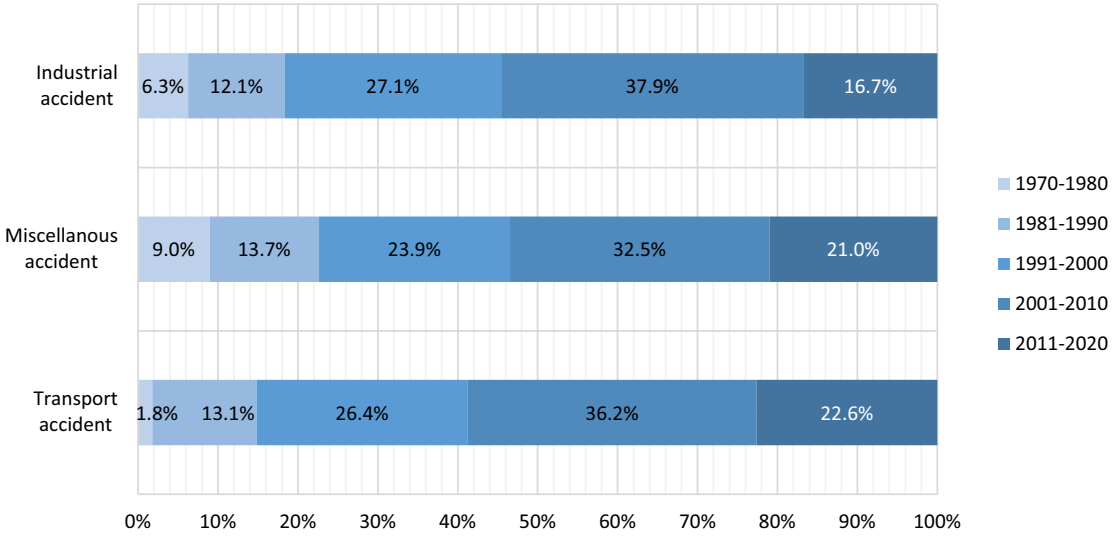

Figure 1. Change of disaster types by decades according to the records of the international disaster database for the last 50 years.

https://doi.org/10.1017/dmp.2024.167 Published online by Cambridge University Press

Table 1. Descriptive statistics of the last 50 years of records on disasters according to international disaster database records

		n (%)
Decades	2001–2010	3051 (35.9)
	1991–2000	2220 (26.1)
	2011–2020	1815 (21.3)
	1981–1990	1107 (13)
	1970–1980	317 (3.7)
Disaster type	Transportation accidents	5666 (66.6)
	Miscellaneous accidents	1395 (16.4)
	Industrial accidents	1449 (17)
Transportation accidents	Highway	2719 (48)
	Sea route	1484 (26.2)
	Airway	895 (15.8)
	Train	568 (10)
Miscellaneous accidents	Explosion	920 (35.5)
	Fire	875 (33.8)
	Collapse	438 (16.9)
	Other	358 (13.8)
Industrial accidents	Explosion	920 (32.3)
	Fire	875 (30.8)
	Collapse	438 (15.4)
	Other	358 (12.6)
	Chemical leakage	107 (3.8)
	Poisoning	73 (2.6)
	Gas leakage	57 (2)
	Radiation	8 (0.3)
	Oil spill	8 (0.3)
Continents	Asia	3879 (45.6)
	Africa	2220 (26.1)
	America	1359 (16)
	Europe	995 (11.7)
	Oceania	57 (0.7)

Descriptive statistics were given as numbers (percentages).

accidents were most often caused by fire and explosion, and transport accidents were most frequently caused by road accidents (or train accidents from 1970–1980). While transportation accidents were mostly seen on the African continent, when transportation accidents are examined by region, airway accidents were the most common accident subtype in Europe and Oceania, and road accidents were the most common accident subtype in Asia, South and North America, and Africa. Miscellaneous and industrial accidents were most frequently observed in Oceania, followed by Asia and the European continent; fires in Europe, South and North America, and Oceania, explosions in Asia, and collapses in Africa were the most common industrial and miscellaneous accidents.

It has been stated that technological disasters come with industrialization, which is marked by technological development and adaptation.[4] No country can be excluded from technological disasters unless the technologies are used perfectly and without human error. Technological disasters in rapidly developing countries (Asian countries: India, China, Bangladesh, and Japan; North American countries: USA, Mexico, and Canada; European countries: Russia, Germany, France, the United Kingdom, and Belgium; African countries: Nigeria, South Africa, Algeria, and Congo; and Middle Eastern countries: Iran, Turkey, and Egypt) have been reported to have more destructive effects, while countries in Oceania and other African countries have been reported to be exposed to less destructive effects.[4] In our study, it was determined that miscellaneous and industrial disasters were most frequently seen in Oceania, followed by Asia and Europe, while transport accidents were most frequently seen in Africa.

We found that the most common cause of technological disasters was transportation accidents, specifically road traffic accidents. In another study, it was reported that the most common cause of mass casualty events was road accidents.[5] Despite significant investments in manpower, materials, and financial resources, road accidents have still been reported as the main cause of death and injury. Major road accidents are seen as an important issue in terms of safety management in various countries around the world.[6] The causes of road accidents can be explained by individual factors vehicle, road, weather, and management factors. Individual factors include excessive speed, fatigue, lack of protective equipment, lack of knowledge of local driving rules, alcohol or drug use, sleepy driving, gender, and age. Vehicle factors include vehicle overload, vehicle volume, and the condition of tires. Road factors include road surface types, road length, horizontal curvature of the road, road friction, average daily traffic flow, daily average truck percentage, large traffic volume, excessive speed, narrow lane widths, greater number of lanes, urban road sections, narrow banquet widths, and reduced medium widths have been shown to increase the probability of accidents. Weather factors (precipitation, fog, dust, rain, snow, and high temperatures) and driving errors have been identified as the main contributing factors in about two-thirds of road accidents. Management factors, traffic rules, and legislation can reduce or control the rate of traffic violations, thus reducing serious injury and death incidents.[7] While fewer aircraft accidents have been reported as being investigated, larger aircraft accidents have been reported to be more common in winter, and professional pilots have been reported to have superior results in terms of safety.[8]

It was determined that industrial disasters were most frequently caused by fires and explosions; industrial accidents were most frequently seen in Oceania, followed by Asia and the European continent; fire was the most common cause in Europe, South and North America, and Oceania; explosions were the most common cause in Asia; and collapses were the most common cause in Africa. It has been reported that industrial accidents in Asia are mostly caused by mining accidents in China and that mining accidents are mostly caused by explosions.[9]

Disaster management has been reported to consist of four stages: prevention and reduction, preparation, response, and recovery.[10] Risk analysis, hazard zone mapping, resource allocation, climate estimation, and determination of building warning codes have been reported to play an important role in the prevention and reduction step.[10] Another article suggested that epidemiology plays

https://doi.org/10.1017/dmp.2024.167 Published online by Cambridge University Press

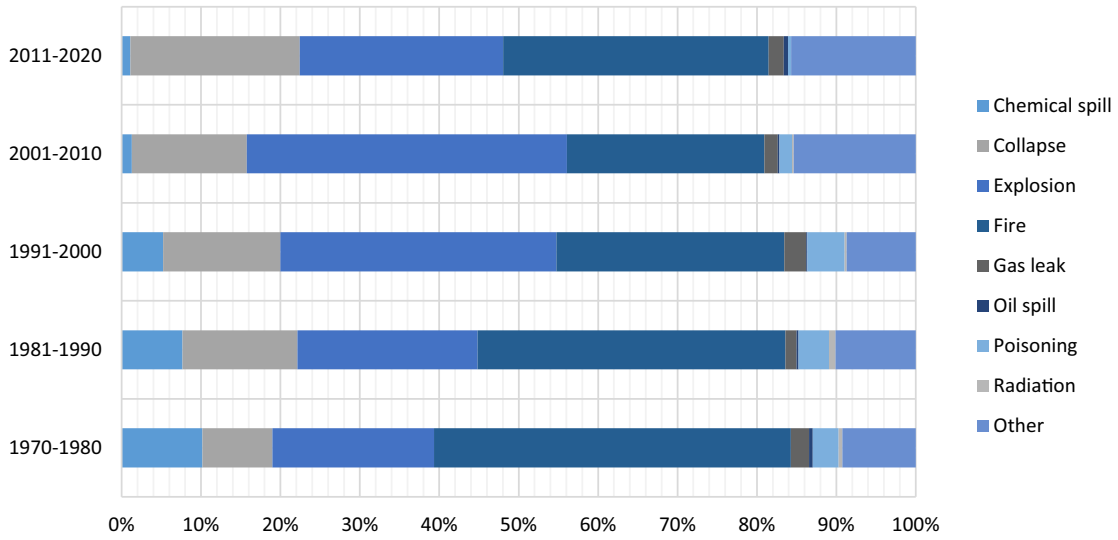

Figure 2. Change of industrial accident sub types within decades according to the records of the international disaster database for the last 50 years.

Table 2. Comparison of the change in disaster types in the last 5 decades according to international disaster database records

	Disaster type			
	Transportation accidents	Miscellaneous accidents	Industrial accidents	*P* value
Decades				
1970–1980	101.0 (1.8) a	125.0 (9.0) b	91.0 (6.3) c	< 0.001
1981–1990	741.0 (13.1) a	191.0 (13.7) a	175.0 (12.1) a	
1991–2000	1495.0 (26.4) a	333.0 (23.9) a	392.0 (27.1) a	
2001–2010	2049.0 (36.2) a	453.0 (32.5) b	549.0 (37.9) a	
2011–2020	1280.0 (22.6) a	293.0 (21.0) a	242.0 (16.7) b	

*Pearson Chi-Square.
Descriptive statistics were given as numbers (percentages).
a, b, c: Letters showing significant differences between the groups.
Column percentage is given.

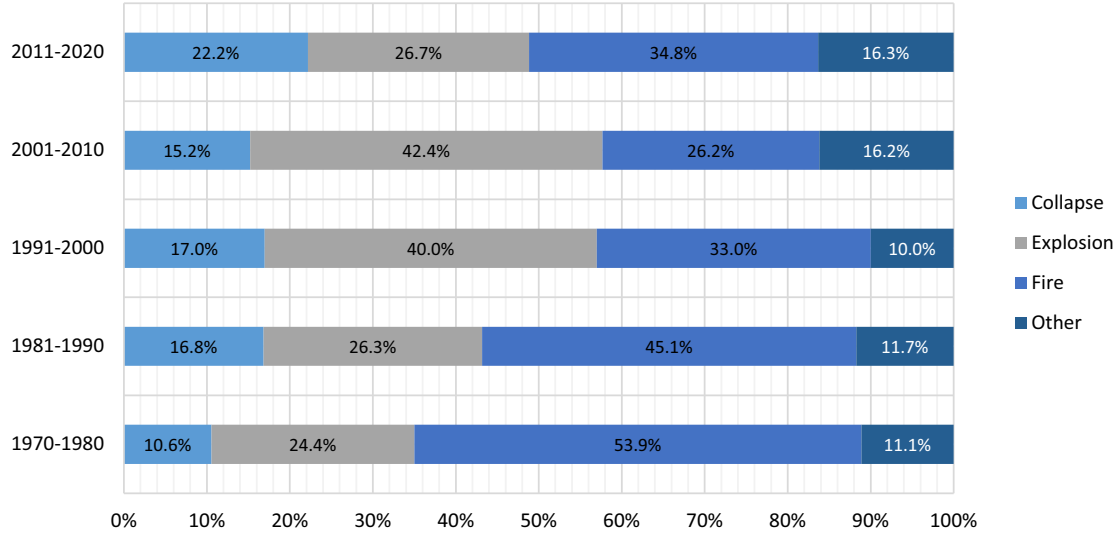

Figure 3. Variation of miscellaneous accident sub types within decades according to the records of the international disaster database for the last 50 years.

https://doi.org/10.1017/dmp.2024.167 Published online by Cambridge University Press

Table 3. Comparison of changes observed in the frequency of each type of disaster during the last 5 decades according to international disaster database records

	Disaster type			
	Transportation accidents	Miscellaneous accidents	Industrial accidents	*P* value
Decades				
1970–1980	101.0 (31.9) a	125.0 (39.4) a	91.0 (28.7) a	**< 0.001**
1981–1990	741.0 (66.9) b	191.0 (17.3) b	175.0 (15.8) b,c	
1991–2000	1495.0 (67.3) b	333.0 (15.0) b	392.0 (17.7) c	
2001–2010	2049.0 (67.2) b	453.0 (14.8) b	549.0 (18.0) c	
2011–2020	1280.0 (70.5) c	293.0 (16.1) b	242.0 (13.3) b	

*Pearson Chi-Square.
Descriptive statistics were given as numbers (percentages).
a, b, c: Letters showing significant differences between the groups.
Row percentage is given.

Table 4. Descriptive statistics of disaster sub types according to the last 5 decades of the international disaster database

	Decades				
	1970–1980	1981–1990	1991–2000	2001–2010	2011–2020
Transportation accidents					
Airway	35.0 (34.7)	179.0 (24.2)	301.0 (20.1)	240.0 (11.7)	140.0 (10.9)
Train	38.0 (37.6)	117.0 (15.8)	200.0 (13.4)	131.0 (6.4)	82.0 (6.4)
Highway	14.0 (13.9)	239.0 (32.3)	670.0 (44.8)	1161.0 (56.7)	635.0 (49.6)
Sea route	14.0 (13.9)	206.0 (27.8)	324.0 (21.7)	517.0 (25.2)	423.0 (33.0)
Miscellaneous accident					
Collapse	19.0 (10.6)	53.0 (16.8)	107.0 (17.0)	145.0 (15.2)	114.0 (22.2)
Explosion	44.0 (24.4)	83.0 (26.3)	252.0 (40.0)	404.0 (42.4)	137.0 (26.7)
Fire	97.0 (53.9)	142.0 (45.1)	208.0 (33.0)	249.0 (26.2)	179.0 (34.8)
Other	20.0 (11.1)	37.0 (11.7)	63.0 (10.0)	154.0 (16.2)	84.0 (16.3)
Industrial accidents					
Chemical spill	22.0 (10.2)	28.0 (7.7)	38.0 (5.2)	13.0 (1.3)	6.0 (1.1)
Collapse	19.0 (8.8)	53.0 (14.5)	107.0 (14.8)	145.0 (14.5)	114.0 (21.3)
Explosion	44.0 (20.4)	83.0 (22.7)	252.0 (34.8)	404.0 (40.3)	137.0 (25.6)
Fire	97.0 (44.9)	142.0 (38.8)	208.0 (28.7)	249.0 (24.9)	179.0 (33.5)
Gas leakage	5.0 (2.3)	5.0 (1.4)	20.0 (2.8)	17.0 (1.7)	10.0 (1.9)
Oil spill	1.0 (0.5)	1.0 (0.3)	1.0 (0.1)	2.0 (0.2)	3.0 (0.6)
Poisoning	7.0 (3.2)	14.0 (3.8)	34.0 (4.7)	16.0 (1.6)	2.0 (0.4)
Radiation	1.0 (0.5)	3.0 (0.8)	2.0 (0.3)	2.0 (0.2)	0.0 (0.0)
Other	20.0 (9.3)	37.0 (10.1)	63.0 (8.7)	154.0 (15.4)	84.0 (15.7)

Descriptive statistics were given as numbers (percentages).
Column percentage is given.

an important role in determining effects on health and identifying the source.[11] We hope that this study will play an important role in reducing technological disasters by examining their distribution by global continent, year, and subtype.

Limitations

EM-DAT is a comprehensive database of disaster events that includes information on natural disasters, technological accidents, and human-made disasters worldwide.[12] However, EM-DAT has

https://doi.org/10.1017/dmp.2024.167 Published online by Cambridge University Press

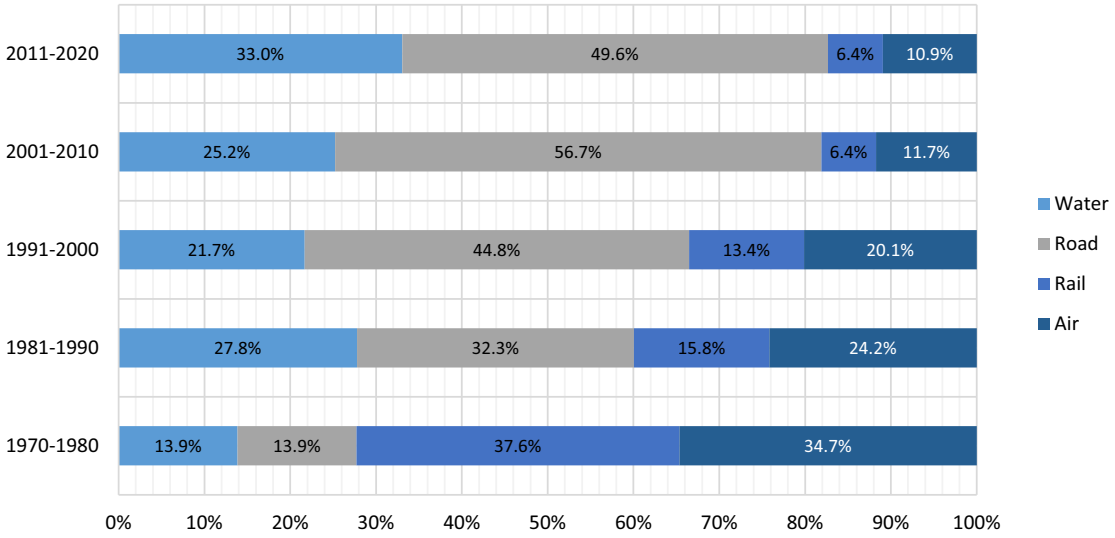

Figure 4. Change of sub types of transport accidents within decades according to the records of the international disaster database for the last 50 years.

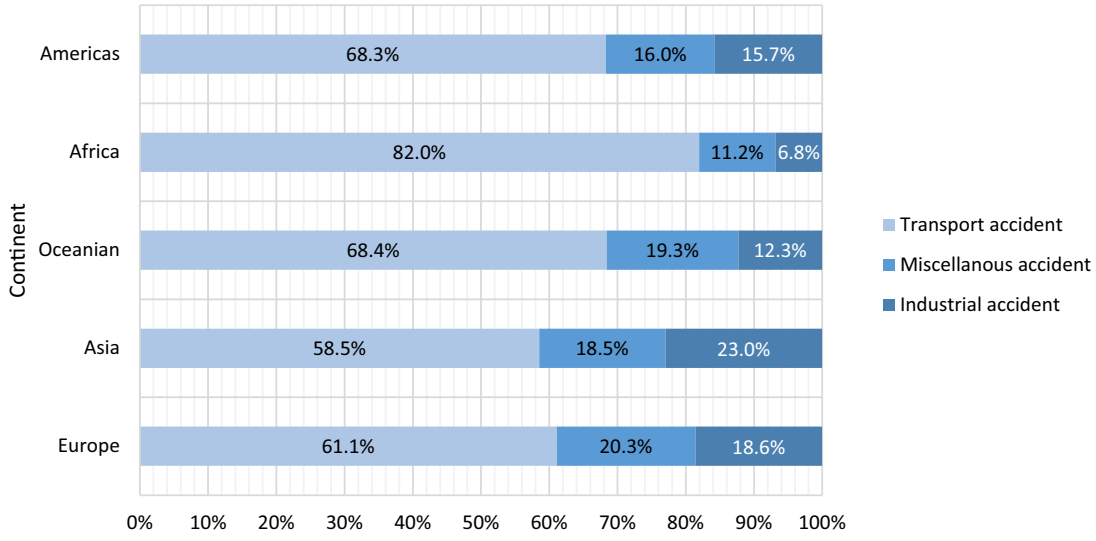

Figure 5. Change of disaster types by decades according to the records of the international disaster database for the last 50 years.

Table 5. Comparison of disaster type and disaster regions according to the records in the last 5 decades of the international disaster database

	Disaster type			
	Transportation accidents	Miscellaneous accidents	Industrial accidents	*P* value
Continents				
Europe	608.0 (61.1) a	202.0 (20.3) a	185.0 (18.6) a	**< 0.001**
Asia	2271.0 (58.5) a	717.0 (18.5) a	891.0 (23.0) b	
Oceania	39.0 (68.4) a, b	11.0 (19.3) a, b, c	7.0 (12.3) a, b, c	
Africa	1820.0 (82.0) c	248.0 (11.2) c	152.0 (6.8) c	
America	928.0 (68.3) b	217.0 (16.0) b	214.0 (15.7) a	

Descriptive statistics were given as numbers (percentages).
*Pearson Chi-Square.
a, b, c: Letters showing significant differences between the groups.
Row percentage is given.

https://doi.org/10.1017/dmp.2024.167 Published online by Cambridge University Press

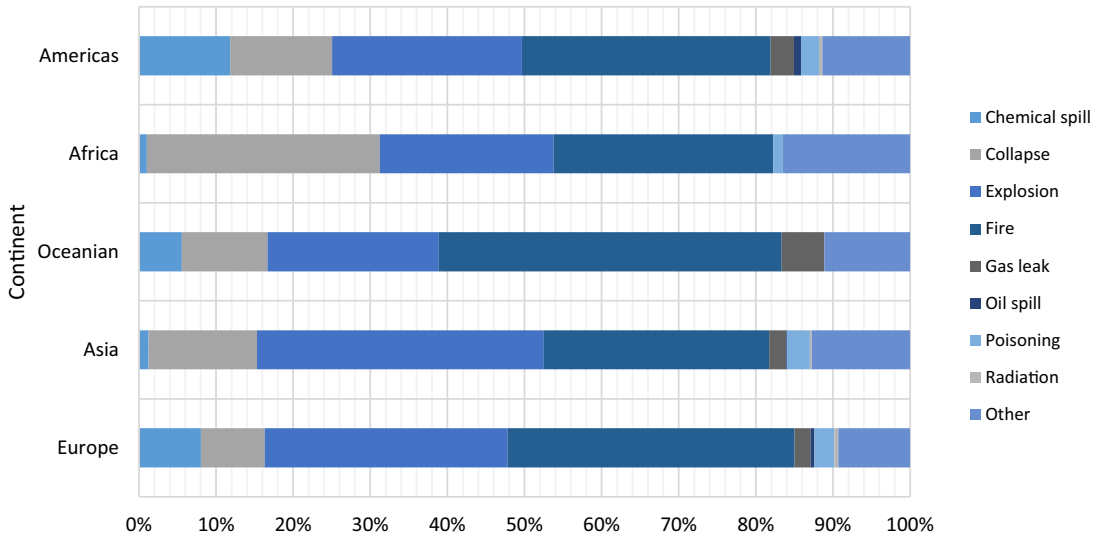

Figure 6. Variation of industrial accident sub types by regions according to the last 50 years records of the international disaster database.

Table 6. Comparison of disaster type and disaster regions according to the records in the last 5 decades of the international disaster database

	Continents				
	Europe	Asia	Oceania	Africa	America
Transportation accidents					
Airway	190.0 (31.3)	292.0 (12.9)	18.0 (46.2)	152.0 (8.4)	243.0 (26.2)
Train	112.0 (18.4)	275.0 (12.1)	4.0 (10.3)	105.0 (5.8)	72.0 (7.8)
Highway	154.0 (25.3)	1035.0 (45.6)	4.0 (10.3)	1062.0 (58.4)	464.0 (50.0)
Sea route	152.0 (25.0)	669.0 (29.5)	13.0 (33.3)	501.0 (27.5)	149.0 (16.1)
Miscellaneous accidents					
Collapse	32.0 (9.6)	226.0 (15.1)	2.0 (12.5)	121.0 (30.9)	57.0 (16.2)
Explosion	122.0 (36.5)	598.0 (39.9)	4.0 (25.0)	90.0 (23.0)	106.0 (30.2)
Fire	144.0 (43.1)	470.0 (31.4)	8.0 (50.0)	114.0 (29.2)	139.0 (39.6)
Other	36.0 (10.8)	205.0 (13.7)	2.0 (12.5)	66.0 (16.9)	49.0 (14.0)
Industrial accidents					
Chemical leakage	31.0 (8.0)	20.0 (1.2)	1.0 (5.6)	4.0 (1.0)	51.0 (11.8)
Collapse	32.0 (8.3)	226.0 (14.1)	2.0 (11.1)	121.0 (30.3)	57.0 (13.2)
Explosion	122.0 (31.5)	598.0 (37.2)	4.0 (22.2)	90.0 (22.5)	106.0 (24.6)
Fire	144.0 (37.2)	470.0 (29.2)	8.0 (44.4)	114.0 (28.5)	139.0 (32.3)
Gas leakage	8.0 (2.1)	35.0 (2.2)	1.0 (5.6)	0.0 (0.0)	13.0 (3.0)
Oil spill	2.0 (0.5)	2.0 (0.1)	0.0 (0.0)	0.0 (0.0)	4.0 (0.9)
Poisoning	10.0 (2.6)	48.0 (3.0)	0.0 (0.0)	5.0 (1.3)	10.0 (2.3)
Radiation	2.0 (0.5)	4.0 0.2	0.0 (0.0)	0.0 (0.0)	2.0 (0.5)
Other	36.0 (9.3)	205.0 (12.7)	2.0 (11.1)	66.0 (16.5)	49.0 (11.4)

Descriptive statistics were given as numbers (percentages).
Column percentage is given.

https://doi.org/10.1017/dmp.2024.167 Published online by Cambridge University Press

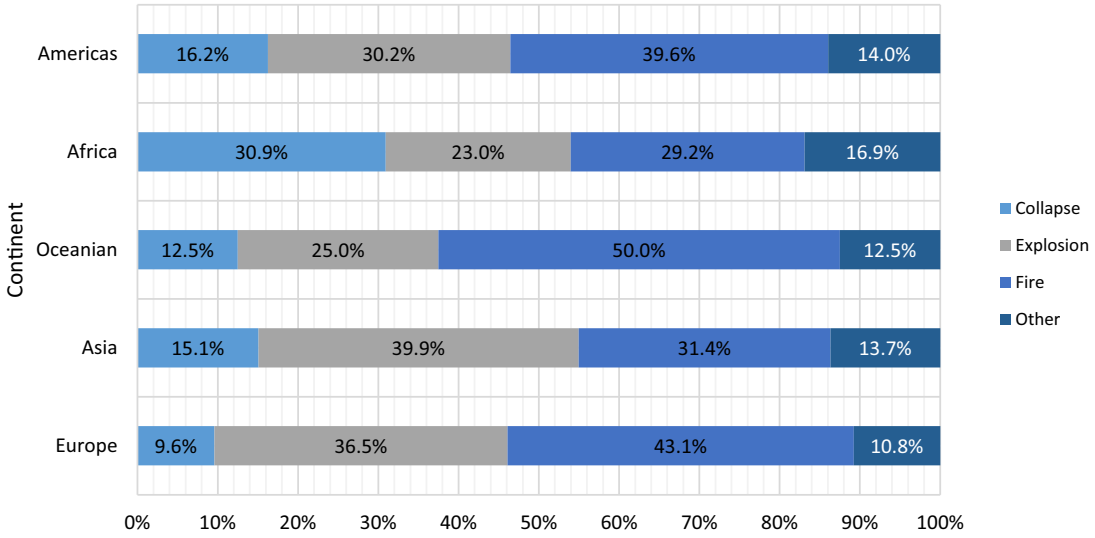

Figure 7. Variation of "miscellaneous accidents" sub types by regions according to the records of the international disaster database for the last 50 years.

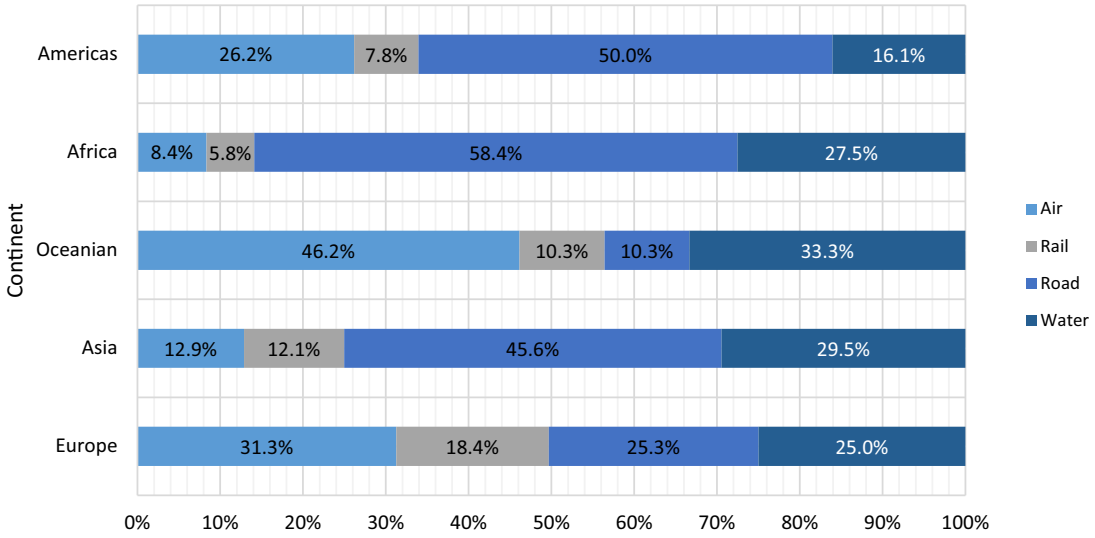

Figure 8. Change of disaster types by decades according to the records of the international disaster database for the last 50 years.

some limitations. EM-DAT may neglect the effects of high-frequency and low-intensity disasters, leading to the overlooking of smaller but frequently recurring events.[12] EM-DAT often measures the severity of disasters based on damage or casualty numbers, which can result in a bias towards highlighting disasters in developed countries and overlooking events in less developed countries.[12] Specific criteria must be met to report a disaster in the EM-DAT database. Events that do not meet these criteria are not included in the database. For example, to record a disaster in the EM-DAT database, at least one of the following criteria must be met: ten or more deaths, 100 or more injuries, a declaration of a state of emergency, or a formal request for international assistance.[12] These limitations indicate that the use of EM-DAT may not be appropriate in certain situations. Researchers and decision-makers should carefully assess disaster data while taking these limitations into account.

Conclusion

Transport accidents have increased significantly over the last 10 years and are the most common cause of technological disasters. Road accidents are the most common type of transport accident.

Acknowledgments. There is no funding statement for this study.

Competing interest. The authors declare that they have no conflicts of interests.

References

1. **Mayhorn CB**, **McLaughlin AC**. Warning the world of extreme events: a global perspective on risk communication for natural and technological disaster. *Saf Sci.* 2014;**61**:43–50.
2. **Guha-Sapir D**, **Below R**, **Hoyois P.** EM-DAT: The CRED/OFDA International Disaster Database. *Nature.* 2016.

https://doi.org/10.1017/dmp.2024.167 Published online by Cambridge University Press

3. **Coppola DP**. *Introduction to International Disaster Management*. Elsevier; 2006.
4. **Shen G**, **Hwang SN**. Revealing global hot spots of technological disasters: 1900–2013. *J Risk Res.* 2018;**21**(3):361–93.
5. **Mohanty CR**, **Radhakrishnan RV**, **Stephen S**, et al. Epidemiology of mass casualty incidents in a tertiary care trauma center in eastern India: a retrospective observational study. *Turk J Emerg Med.* 2022;**22**: 96–103.
6. **Carmo EA**, **Nery AA**, **Rocha RM**. Repercussions of traffic accidents: an integrative review. *Rev Pesqui Cuid E Fundam.* 2019;**11**:732.
7. **Lei Y**, **Zhang G**, **Lu S**, et al. Generation paths of major road accidents based on fuzzy-set qualitative comparative analysis. *Int J Environ Res Public Health.* 2022;**19**(21):13761.
8. **Liebold F**, **Hippler C**, **Schmitz J**, et al. Fixed-wing motorized aircraft accidents: analysis of injury severity and concomitant factors (2000-2019). *Aerosp Med Hum Perform.* 2022;**93**(5):442–449.
9. **Chu C**, **Jain R**, **Muradian N**, et al. Statistical analysis of coal mining safety in China with reference to the impact of technology. *J South Afr Inst Min Metall.* 2016;**116**:73–8.
10. **Iqbal U**, **Perez P**, **Barthelemy J.** A process-driven and need-oriented framework for review of technological contributions to disaster management. *Heliyon.* 2021;**7**(11):e08405.
11. **Bertazzi PA**. Industrial disasters and epidemiology. A review of recent experiences. *Scand J Work Environ Health.* 1989;**15**(2):85–100.
12. **Mazhin SA**, **Farrokhi M**, **Noroozi M**, et al. Worldwide disaster loss and damage databases: a systematic review. *J Educ Health Promot.* 2021;**10**:329.

https://doi.org/10.1017/dmp.2024.167 Published online by Cambridge University Press