Disaster Medicine and Public Health Preparedness

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National Burden and Epidemiological Features of Mass Casualty Incidents in Spain, from 2014 to 2022

Pedro Arcos González, Rick Kye Gan and José Antonio Cernuda Martínez

Unit for Research in Emergency and Disaster, Department of Medicine, Universidad de Oviedo, Oviedo, Spain

Original Research

Cite this article: Arcos González P, Gan RK and Cernuda Martínez JA (2024). National Burden and Epidemiological Features of Mass Casualty Incidents in Spain, from 2014 to 2022. *Disaster Medicine and Public Health Preparedness*, **18**, e281, 1–5
https://doi.org/10.1017/dmp.2024.299

Received: 11 February 2024
Revised: 31 August 2024
Accepted: 05 October 2024

Keywords:
mass casualty incident; emergency; disaster; epidemiology; national burden

Corresponding author:
Rick Kye Gan;
Email: ganrick@uniovi.es

Abstract

Objectives: Mass Casualty Incidents (MCIs) pose significant challenges to health care systems, especially regarding emergency preparedness and response. This study aims to analyze the epidemiological characteristics and burden of MCIs in Spain from 2014 to 2022, focusing on the type, frequency, and impact of these incidents on public health and emergency services.

Methods: A population-based retrospective observational study examined MCIs in Spain between January 2014 and December 2022. Data were collected from various emergency services. Incidents involving 4 or more victims requiring medical assistance and ambulance mobilization were included. The study categorized MCIs into 5 types: road traffic accidents, fires and explosions, chemical poisonings, maritime accidents, and others.

Results: A total of 1618 MCIs resulting in 8556 victims were identified, averaging 15 (95% CI, 11-19) incidents per month, with 79% due to road traffic accidents and 13% to fires and explosions, which also had the highest average of 7.6 victims per incident. Despite maritime accidents comprising only 1.9% of incidents, they had the highest fatality rate. MCIs were more frequent on weekends, in January and July, and between 3:00 PM and 9:00 PM. The average response time was 38 minutes, with 35% of victims sustaining severe injuries.

Conclusions: Despite a slight decrease in annual MCIs from 2014 to 2022 in Spain, the trend is not statistically significant. The study highlights the need for a national registry and standardized data collection to enhance emergency preparedness and response planning and facilitate the reduction of the MCI burden.

A Mass Casualty Incident (MCI) is an event where the number of victims exceeds local resources, requiring exceptional emergency arrangements and additional assistance. The World Health Organization defines MCI as "disasters and major incidents characterized by quantity, severity, and diversity of patients that can rapidly overwhelm the ability of local medical resources to deliver comprehensive and definitive medical care."[1]

An MCI is quantitatively difficult to define due to the absence of a unanimous agreement on the minimum number of victims to consider an incident as an MCI. Nevertheless, in MCIs, victims from diverse hazards often overwhelm health care services.[2–4] Therefore, the importance of an MCI depends significantly on the context and the capacity of the national and regional health care system and additional resources such as the number of on-call teams in the area where it occurs.

Studies on the burden of MCIs in Spain are, to date, limited to certain regions, as little research has been conducted, and models have been proposed for standardized data collection.[5,6] MCI in Spain is defined as an incident involving 4 or more victims requiring ambulance mobilization.[7,8] Currently, there is no national registry of MCIs in Spain, and their frequency and epidemiological characteristics at the national level have not yet been described.

Understanding the burden of MCIs in national contexts is important for disaster preparedness and response planning, as it will enable the identification of challenges and limitations.[9] This understanding must be aligned with pre-existing emergency care and trauma systems, which play an essential role in providing an effective initial response to mass casualty management. It is also vital for the continuity of care in everyday emergencies. In the immediate aftermath of a large-scale disaster, the pre-existing emergency care and trauma systems are likely to be the major functioning platforms for maintaining general health care services and critical care.[1,10]

This study aimed to explore the MCI burden in Spain and characterize its main epidemiological features, and to provide insights into MCIs and their impact on public health and safety.

Methods

A population-based retrospective observational study was conducted to explore MCIs that occurred in Spain between January 2014 and December 2022. Data on these MCIs were gathered

Table 1. Key characteristics of MCIs in Spain, 2014-2022

Type	*N* (%)	Victims *N* (%)	Victims/MCI (*CI* 95%)	Fatalities (%)	Fatalities/MCI (*CI* 95%)
Road traffic accident	1279 (79.0)	6282 (73.4)	4.9 (3.8–6.0)	186 (51.5)	0.14 (0–0.4)
Fire and explosion	211 (13.0)	1613 (18.7)	7.6 (6.3–8.9)	16 (4.4)	0.07 (0–0.1)
Chemical Poisoning	76 (4.7)	305 (3.4)	4.0 (3.4–4.6)	18 (5.0)	0.23 (0–0.3)
Maritime accident	31 (1.9)	195 (2.7)	6.2 (4.1–8.3)	96 (26.6)	3.0 (2–5)
Others	21 (1.3)	161 (1.8)	7.6 (5.2–10)	45 (14.4)	2.4 (0–6.2)
Total	1618 (100)	8556 (100)	5.2 (4.1–6.3)	361 (100)	0.22 (0–7.1)

from the National Health System Emergency Services, the Directorate General of Traffic of Spain, the Maritime Rescue Service, and the Firefighting and Civil Protection Services in Spain.

The inclusion criteria for MCIs were incidents involving 4 or more individuals who required medical assistance and the mobilization of at least 1 ambulance, regardless of the ambulance type. The criteria included individuals who were deceased at the scene or during ambulance transfer but excluded those who passed away during subsequent care, such as hospitalization. Medium and long-term injuries or mental health issues resulting from the incident were also excluded from the criteria.

MCIs were categorized into 5 types based on their nature: road traffic accidents, fires and explosions, chemical poisoning, maritime accidents, and others, such as carbon monoxide intoxication due to incomplete combustion of stoves in poor condition, structural or building collapse, mass food poisoning. A victim was defined as a person directly affected by the MCI who required immediate medical assistance following the incident. The medical officer of the first ambulance arriving at the scene is responsible for determining whether victims require evacuation and treatment at a medical facility, as well as identifying the appropriate type of facility. The MCI event decision is made in coordination with the emergency coordination center.

The variables studied included MCI frequency, type of MCI, response time, number of victims, severity of victims, number of fatalities, time, day of the week, month of occurrence, and the need for rescue. The average response time to the incident was defined as the time elapsed between the initial emergency system alert and the arrival of the first health care resource at the scene.

Statistical analysis was performed using absolute and relative frequencies to establish the profile and characteristics of MCIs. Mean values, along with their 95% confidence intervals (*CI* 95%), were used. The statistical analysis employed the Chi-square test and regression analysis. All statistical analyses were conducted using the StatPlus statistical software (©2023 AnalystSoft Inc.).

Results

Between 2014 and 2022, there were 1618 MCIs in Spain, resulting in 8556 victims were identified, with an annual average of 179 MCIs (95% *CI*, 155-204) and an average incidence rate of 0.38 MCIs per 100 000 inhabitants per year. Of the total MCIs, 79.0% were road traffic accidents, 13.0% were fires and explosions, 4.7% were chemical poisonings, 1.9% were maritime accidents, and 1.3% were other types of MCIs, such as carbon monoxide intoxication and food poisoning.

Table 1 presents the characteristics of the MCIs in Spain during the study period. These incidents resulted in a total of 8556 victims, with an average of 5.2 victims per MCI (95% *CI*, 4.1-6.3). Nearly three-quarters (73.4%) of these victims were associated with road traffic MCIs, followed by MCIs caused by fires and explosions (18.7%).

MCIs due to fires and explosions, along with MCIs of other types, had the highest average number of victims per incident, both with 7.6 (95% *CI*, 6.3-8.9) and (95% *CI*, 5.2-10, respectively). MCIs caused by fires and explosions had significantly ($P = 0.045$) more victims than other types of MCIs, while those caused by chemical poisoning had significantly ($P = 0.048$) fewer. Figure 1 illustrates the distribution of MCIs based on the number of victims produced. Sixty-eight percent of MCIs resulted in 5 or fewer victims per incident, with only 32% involving more than 6 victims.

The average response time to the incident, recorded in 72% of MCIs, was determined to be 38 minutes (95% *CI*, 28.3-47.7). Information on the severity of victims was recorded in 67% of the MCIs, with 65% (95% *CI*, 50.2-79.8) classified as having minor injuries and 35% (95% *CI*, 20.6-49.4) as having severe injuries. MCIs caused by fires and explosions, along with MCIs of other types, had the highest average number of victims per incident, both with 7.6 (95% *CI*, 6.3-8.9 and 95% *CI*, 5.2-10, respectively). MCIs caused by fires and explosions had significantly ($P = 0.043$) more victims than other types of MCIs, while those caused by chemical poisoning had significantly ($P = 0.038$) fewer.

Fifty-one-point five percent (51.5%) of the fatalities occurred in road traffic MCIs, and 26.6% occurred in maritime MCIs. Maritime MCIs had a significantly higher ($P = 0.035$) average number of fatalities per incident, 3.0 (95% *CI*, 2-5), compared to other types of MCIs, which had an average of 2.4 fatalities per incident (95% *CI*, 0-6.2). Characteristics of maritime accidents, such as shipwrecks, and other MCI incidents like carbon monoxide intoxications and

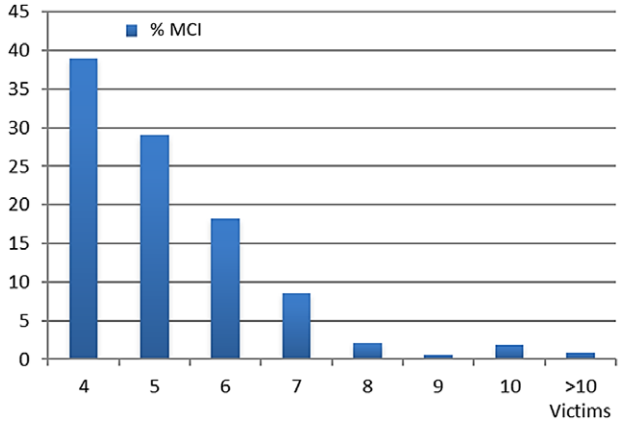

Figure 1. Distribution of MCIs in Spain by the number of victims, 2014-2022.

https://doi.org/10.1017/dmp.2024.299 Published online by Cambridge University Press

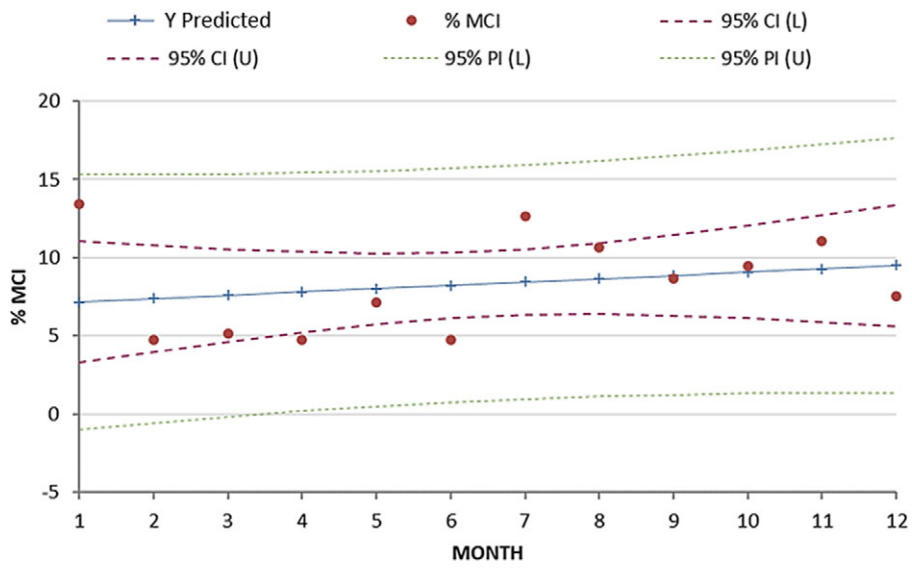

Figure 2. Frequency of MCIs by month in Spain, 2014-2022.

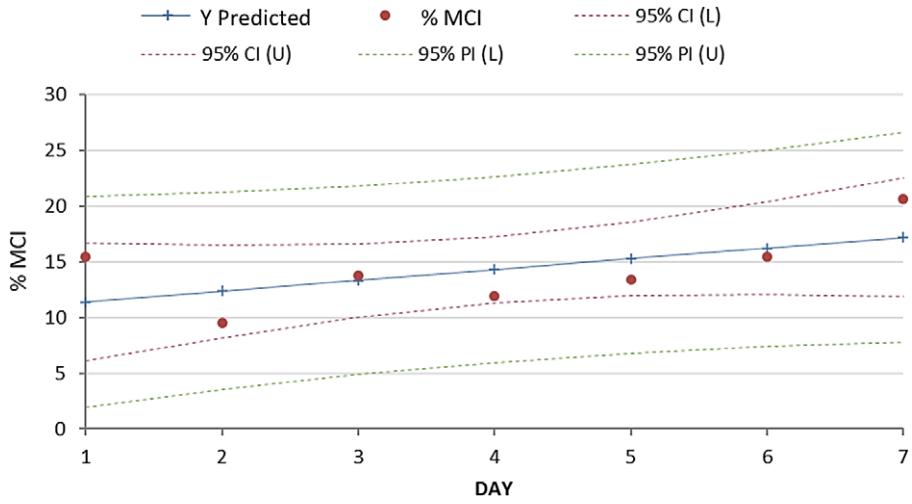

Figure 3. Frequency of MCIs by day of the week in Spain, where 1 means the first day of the week (Monday), and 7 (Sunday), 2014-2022.

infrastructure collapse, although infrequent, were found to have a higher fatalities per MCI. In 78% of the MCIs, it was recorded whether the incident required victim rescue efforts, with an estimated rescue frequency of 32% (95% *CI*, 16.8-47.2). Traffic accidents and fires and explosions were the types of MCIs that most frequently required rescue efforts, with 40% (95% *CI*, 35.2-44.8) and 60% (95% *CI*, 45.5-74.5), respectively.

Figure 2 displays the frequency of MCIs by month. The monthly average of MCIs for the entire study period was 15 MCIs (95% *CI*, 11-19), with significant increases ($P = 0.046$) in the frequency of MCIs in January and July, as well as significant reductions ($P = 0.042$) in April and June. Although there is an overall increase in the frequency of MCIs throughout the months of the year, the regression analysis did not show statistical significance.

The distribution of MCIs by days of the week is shown in Figure 3, and the distribution of MCIs according to the time of day of occurrence is shown in Figure 4. The regression analysis indicates a significantly increasing trend ($P = 0.044$) in the frequency of MCIs coinciding with weekends. The absolute annual frequency of MCIs has been decreasing slightly during the period 2014-2022, as shown in Figure 5. However, this decrease was not statistically significant ($P = 0.07$).

Discussion

This study analyzes the epidemiological characteristics and burden of MCIs in Spain over 9 years, focusing on various aspects such as the types, frequency, and impact of these incidents on public health and emergency services. The average incidence rate for 2014-2022 in Spain was 0.38 MCIs per 100 000 inhabitants yearly. Although there are some studies on the incidence of MCIs in other countries,[11–14,16] the differences between the characteristics in terms of inclusion criteria, study design, study scope, characteristics of health care facilities and emergency systems, as well as demographic, geographic, climatic, social, economic, and industrial characteristics of each area, make it challenging to draw relevant conclusions.

https://doi.org/10.1017/dmp.2024.299 Published online by Cambridge University Press

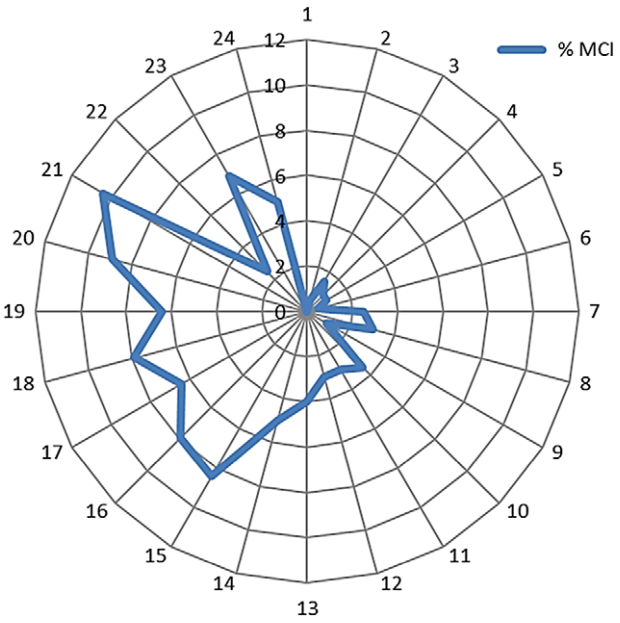

Figure 4. displays the distribution of MCIs according to the time of day of occurrence. MCIs are significantly ($P = 0.034$) more frequent between 15:00 and 21:00.

Nevertheless, it is possible to find some common findings in the studies, [15–17] including our own, such as the most frequent type of MCI being due to a road traffic incident, as well as the concentration of MCIs during time periods with higher activity or on specific days of the week. In both cases, this is likely because there is higher road traffic activity during those time periods. The annual frequency of MCIs slightly decreased in Spain during the period 2014-2022, but this decrease was not statistically significant, probably because the studied time series (9 years) is still too small to demonstrate significance.

There are several significant challenges in the study of MCI epidemiology. The first relates to the absence of a standardized and uniformly accepted definition of the phenomenon, not only in terms of its quantitative element, such as the minimum number of victims, but also the definition of a victim. The absence of these standardized criteria hampers the comparability of studies and highlights the need for consensus and uniformity in MCI definitions to advance future research and improve the effectiveness of emergency response strategies.

The second challenge is the absence of population-based MCI registries. Although there are MCI databases with different geographical coverage,[18,19] the lack of a defined population base in many of them and the absence of common inclusion criteria limit comparability between them and facilitate selection biases.[20] In the case of Spain, there is currently no national registry of MCIs, and it is particularly difficult to find information on specific aspects of MCIs, such as the type of victims, their severity, non-immediate mortality, or the characteristics of the health care devices used.

Despite the challenges, studying the national burden of MCIs from an epidemiological perspective in the context of geographic and socioeconomic status is essential and indispensable for mass casualty management preparedness and response planning. Evaluating the local situation, which includes an "all-hazard" approach, aligns with the Sendai Framework's first priority: understanding disaster risk. Such understanding will eventually enable the strengthening of disaster risk management and governance, investment in risk reduction for resilience, and enhancement of disaster preparedness for effective response.[21]

Our study also included several limitations. It is possible that the number of victims involved in our MCIs was underestimated. For instance, there is a potential reporting bias for RTIs with minor injuries occurring in remote or underserved regions. Also, mortality may have been underestimated by including only immediate but not final mortality, such as from hospitalization outcomes. This limitation also highlights the importance of structured data collection by the emergency medical services and integration with the hospital facilities. Therefore, it is very relevant to improve research on MCIs by having standardized systems for collecting basic MCI data,[22,23] such as command and control, safety, communication, assessment, triage, treatment, and transport (CSCATTT), that use standard and common definitions and inclusion criteria, taking into account the contextual and organizational differences mentioned.

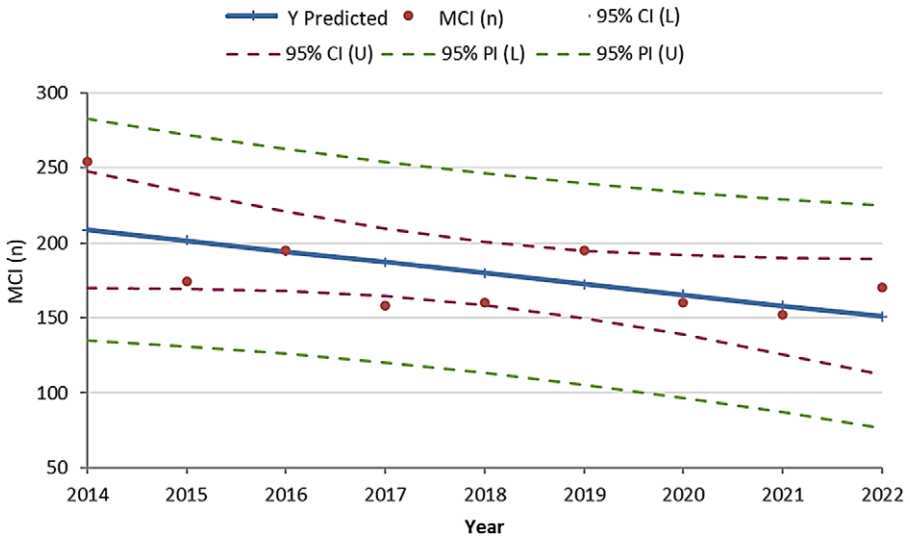

Figure 5. Trend in the frequency of MCIs in Spain, 2014-2022.

https://doi.org/10.1017/dmp.2024.299 Published online by Cambridge University Press

Conclusion

In Spain, despite a slight decrease in annual MCIs from 2014 to 2022, the trend is not statistically significant. Epidemiological information about MCIs in Spain is fragmented and not easily accessible, especially regarding the severity characteristics of the victims and the public health and non-health care emergency resources mobilized. There is a need for systematic and standardized data collection on MCIs in Spain to facilitate the planning of emergency services and programs for the prevention and reduction of the impacts of MCIs.

Authors contribution. All authors contributed equally to conception, design, data acquisition, and analysis. Each participated in drafting or critically revising the manuscript, approved the final version for publication, and accepted accountability for all aspects of the work.

Competing interest. All authors declare no conflicts of interest.

Funding statement. This research received no funding.

Ethical standard. Ethics approval was not required as there was no involvement of patients or members of the public in the design, conduct, reporting, or dissemination plans of the research.

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