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The Epidemiological Profile of Multiple Casualty Incidents in Northern Spain: 2014-2020

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Abstract

Objective: To describe the epidemiological profile of multiple casualty incidents (MCI) and contribute to the better understanding of their impacts in Northern Spain.
Method: Retrospective, population-based observational study of MCI between 2014 and 2020 in 5 autonomous communities (Aragón, Castilla y León, Galicia, the Basque Country and Principado de Asturias) that participated in the MCI Database of Northern Spain. Inclusion criteria was any incident with 4 or more patients needing ambulance mobilization. A total of 54 variables were collected. This study presents the most relevant results.
Results: There were 253 MCI. Of these, 79.8% were road traffic accidents, 12.3% fires or explosions, 2.0% poisonings and 5.9% defined as others. Monthly average was 2.9 (SD = 0.35; EEM = 15.90), average of victims by MCI was 6.8 (CI95% 6.16 - 7.60). There were significantly ($P < 0.05$) more victims in 3 types of MCI (fires, poisonings, and others). We saw 37.7% of MCI involved 4 victims, 18.8% 5 victims, and 37.9% more than 5. Mean response time was 30.8 minutes (95% CI 28.6 - 33.1), longer in maritime incidents. A total of 67% (95% CI 64.5 - 69.5) of victims were mild.
Conclusions: Road traffic accidents are the most frequent MCI and minor injuries predominate. More than 50% of the MCI have 5 or fewer patients. Fires had significantly more mild patients and significantly more resources deployed. Maritime incidents had a significantly longer response time.

What is already known about this subject

Multiple casualty incidents (MCI) are a rare phenomenon in comparison to other health issues but have a great impact on health care. Very few population-based studies exist, and most published papers refers to specific incidents published as interesting lessons learnt with poor scientific evidence.

What this study adds

This study adds a feasible methodology which facilitates a scientific approach to MCI analysis. This approach is made possible thanks to the development of a population-based database that collect all MCI in the northern part of Spain. This has allowed us to get to know the epidemiological profile of MCI in an important geographical area of Spain, as a first step to adapt resources and response to this specific profile (in our case MCI for road traffic accidents).

Introduction

Multiple casualty incidents (MCI) are phenomena difficult to define, especially in *quantitative* terms. MCI involves several victims, but it is not clear the number of them to be considered as MCI. Different organizations have different definitions mainly based on the characteristics of the phenomenon they are most interested in considering or measuring. For instance, the World Health Organization (WHO) considers MCI as *'events which generate more patients at 1 time than locally available resources can manage using routine procedures and requiring exceptional emergency arrangements and additional or extraordinary assistance.'*[1] The UK National Health Service defines major incident (MI) as *'any occurrence that presents a serious threat to the health*

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of the community, disruption to the service, or causes such a number or type of casualties so as to require special arrangements to be implemented by hospitals, ambulance trusts or primary care organizations.'[2] It is important to note that most of the definitions focus on the balance between the resources and needs required to respond to the emergency, without independently considering the number of victims. This approach makes the concept totally dependent on the *context* in which the emergency occurs and limits the comparability of the results of the MCI studies.

There have been different attempts to create MCI databases,[3–5] some of them even country-based,[6] but none of them have been developed from a population-based approach and specific experiences predominate.[7] Some databases depend on the researcher's intention to upload the data, having an important selection bias.[8] Till date, reporting MCI in the scientific literature has been widely used to share experiences,[9] but this approach lacks the necessary scientific background and may be biased by personal experiences.

The first epidemiological analysis of the MCI profile in Spain was made in 2014 with data from the Emergency Medical System (EMS) of 1 of its regions (Principado de Asturias).[10] A similar study was published the same year in Korea.[11] Since then, a new MCI database covering Northern Spain has been developed gathering data from 5 Spanish regions (Aragón, Castilla y León, Galicia, País Vasco and Principado de Asturias) corresponding to 37.42 % of the Spanish territory. A first epidemiological analysis from the data of this new MCI database for the period 2014 to 2020 is shown in this paper.

To provide a base to study MCI, the Northern Spain Disaster Working Group and the Unit for Research in Emergency and Disaster of University of Oviedo have developed a uniform reporting template for MCI in Spain.[12] The main inclusion criterion for MCI is an incident involving 4 or more victims. This template measures 54 different variables grouped in 4 categories: MCI description, pre-hospital response, rescue and triage, and improvement actions.

The objective of this population-based study was to identify the epidemiological profile of MCI and contribute to understand the risk factors and impacts in the area covered by the MCI database.

Material and methods

This was a population-based retrospective study of the MCI in 5 regions of Northern Spain (Aragón, Castilla y León, Galicia, País Vasco and Principado de Asturias) between 2014 and 2020. MCI data from these 5 regions were collected by the MCI database of Northern Spain that covers a population of 9 665 416 inhabitants and a geographical extension of 189 357 km^2. All 5 regions have the same type of public healthcare system for 100% of the population. Pre-hospital emergency care is provided by physician staffed EMS teams covering the entire territory and providers trained in basic life support (BLS). All EMS included in the study use the same META triage system developed by the Unit for Research in Emergency and Disaster of University of Oviedo.[13]

Inclusion criteria of MCI were every incident with 4 or more people affected that required ambulance mobilization. Average duration time of an MCI was defined as the time from the first call and the return to service of the last ambulance sent to the incident. For this study, the latest European Union Standards regarding medical vehicles and their equipment were used.[14]

Patients were assigned by a prehospital physician to different categories accordingly to their severity. Categories used were minor, moderate, severe and death. They were classified following the META triage system,[13] which is based on the Advanced Trauma Life Support protocol. The equivalences to the color classification are minor injured - green, moderate - yellow, severe - red and death - black.

Data were collected prospectively from the EMS call center registry and personal interviews were made to MCI first responders when needed. Only 1 person was responsible for detecting MCI and data entry. The doctor who received the call identified every incident with 4 or more patients with a specific icon displayed on the call screen.

A descriptive statistical analysis using absolute and relative frequencies was carried out to establish the profile and characteristics of MCI. We used parameters of central tendency (mean) and dispersion as standard deviation (SD) and standard error of the mean (EM), as well as confidence intervals of 95%.

We used a correlation analysis to establish the relationship between each MCI and resources used. To study temporal trends, we used a linear regression with exponential smoothing to improve data fit. All the statistical analysis was made using SPSS™ v.25 (IBM Corp., Armonk, NY, USA) statistical software.

Patient and public involvement

No involvement from patients or members of the public in the design, or conduct, or reporting, or dissemination plans of the research.

Results

A total of 253 MCI were detected during the period 2014 - 2020 in the 5 regions. Table 1 shows the main features of the MCI. Of these, 202 MCI (79.8%) were road traffic incidents; 31 (12.3%) were fires or explosions; 5 (2.0%) were CO intoxications, and 15 (5.9%) were classified as others, including shipwrecks or food poisoning. Chemical toxic substances were involved in 28 (11.1%) of the incidents.

Average response time to all MCI, defined as the time since the call is received until the first EMS resource arrives, was 30.8 minutes (CI95% 28.6 - 33.1), the response time to MCI maritime incident being significantly higher ($P < 0.05$) and fire emergencies showed a significantly ($P < 0.05$) more prompt response. Average duration time of an MCI, defined as the time from the first call and back to service of the last ambulance, was 86.6 minutes (CI95% 73.7 - 99.5); lower for sea-related ($P < 0.05$), and longer for intoxications and fires ($P < 0.05$).

The mean of EMS units deployed for the total of MCI was 2.8 (CI95% 2.6 - 3.0). Fires had a significantly ($P < 0.05$) higher number of units deployed, while MCI classified as 'others' had a significantly lower number of units deployed ($P < 0.05$).

MCI in which a rescue team was needed was 34% of the total, with traffic accidents and fires more in need ($P < 0.05$), and intoxications and sea-related incidents less in need ($p < 0.05$). Medical care during rescue was needed in 33% of all MCI; whereas this medical care was needed more in road traffic accidents ($p < 0.05$) and less in MCI classified as 'others' ($P < 0.05$).

Table 2 shows that the average number of victims per incident was 6.8 (CI95%6.16 -7.60), with 3 types of incidents (fires, poisoning and others) having significantly ($P < 0.05$) more victims than others, and traffic accidents MCI having significantly ($P < 0.05$) less victims.

Severity of victims based on triage is shown in Figure 1. A total of 67% (CI95% 64.5 -69.5) of victims were minor-injured (green) patients, fires had significantly ($P < 0.05$) more minor-injured patients. Maritime incidents and other type of MCI had a

Table 1. Main features of the MCI (n = 253)

MCI type	n (%) (IC95%)	Response time (min) x̄ (CI95%)	Total duration x̄ min (CI95%)	Units deployed per MCI x̄ (CI95%)	MCI with rescue n (%) (CI95%)	MCI with medicalized rescue n (%) (CI95%)
Traffic accident	202(79.8) (77.6 - 82)	31.3 (28.8 - 33.8)	80.9 (65.9 - 95.9)	2.6 (2.5 - 2.8)	50 (59) (48.4 - 69.3)*	64 (76) (67.1 - 85.3)*
Fire	31 (12.3) (10.5 - 14.1)	26.4 (19.8 - 33.0)*	113.5 (95.1 - 132.0)*	3.2 (2.51 - 3.99)*	23 (27) (17.6 - 36.5)*	16 (19) (10.7 - 27.4)*
Intoxication	11 (4.3) (3.2 - 5.4)	33 (9.8 - 33)	104.9 (-210.21)*	2.6 (1.94 - 3.32)	3 (4) (-7.5)*	3 (4) (-7.5)*
Sea	4 (1.6) (0.9 - 2.3)	37.7 (10.4 - 65.05)*	67.75 (19.6 - 112.8)*	3 (0.74 - 5.2)	4 (5) (0.2 - 9.2)*	0 (0)
Others	5 (2.0) (1.2 - 2.8)	30.4 (0.5 - 60.2)	126.4 (22.5 - 230.2)*	5.2 (1.6 - 8.7)*	5 (6) (0.9 - 10.9)*	1 (1) (-3.5)*
Total	253 (100)	30.8 (28.6 - 33.1)	86.6 (73.7 - 99.5)	2.8 (2.6 - 3.0)	85 (34) (27.8 - 39.4)	84 (33) (27.4 - 39.0)

*Statistically significant differences (< 0.05).

Table 2. MCI victims features and triage

Type	Victims n (%) (CI95%)	MCI n (%) (CI95%)	Victims per MCI x̄ (CI95%)	Green n (%) (CI95%)	Yellow n (%) (CI95%)	Red n (%) (CI95%)	Black n (%) (CI95%)
Traffic accident	964 (72) (69.9 - 74.4)	202 (79.8) (77.6 - 82)	6.06 (5.4 - 6.7)*	615(64)* (60.8 - 66.8)	263(27) (24.5 - 30.1)	62 (6) (4.9 - 8.0)	24 (2) (1.5 - 3.5)
Fire	257 (20) (17.8 - 22.1)	31 (12.3) (10.5 - 14.1)	11.68 (8.3 - 14.9)**	205(80)** (74.9 - 84.7)	47(18) (13.6 - 23)*	4 (2)* (-3.1)	1 (0.3) (-1.2)*
intoxications	48 (4) (2.9 - 5)	11 (4.3) (3.2 - 5.4)	9.60 (2.7 - 16.4)**	43(90)* (85.8 - 93.3)	5(10) (6.7 - 14.2)*	0 (0)	0 (0)
Sea	30 (3) (2 - 3.9)	4 (1.6) (0.9 - 2.3)	7.5 (2.0 - 12.9)	9(30)* (13.6)	9(30) (13.6)**	0 (0)	12 (40)** (22.5 - 57.5)
Others	22 (1) (0.4 - 1.5)	5 (2.0) (1.2 - 2.8)	11 (-23.7)**	13(59)* (38.5 - 79.6)	7(32) (12.4 -51.3)**	2 (9)** (-21.1)	0 (0)
Total	1321 (100)	253 (100)	6.8 (6.1 - 7.6)	885(67) (64.5 - 69.5)	331(25) (22.7 - 27.4)	68 (5) (4.0 - 6.3)	37 (3) (1.9 - 3.7)

*Statistically significant differences (< 0.05).

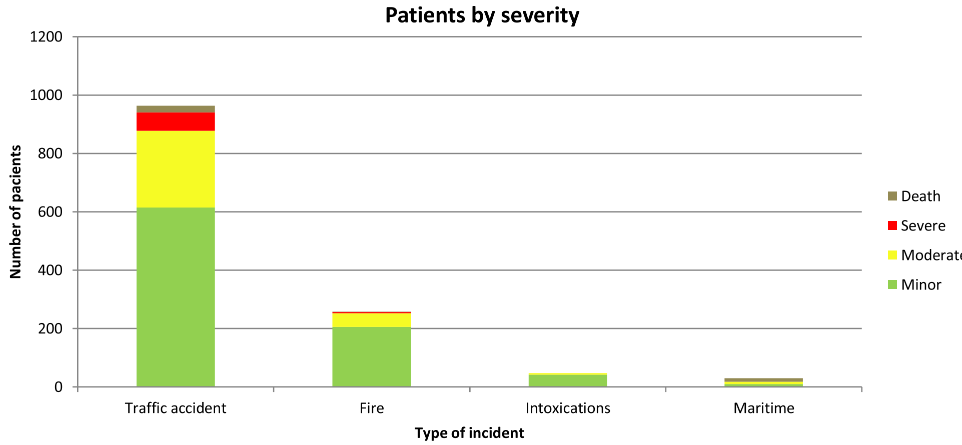

Figure 1. Severity of victims per type of MCI.

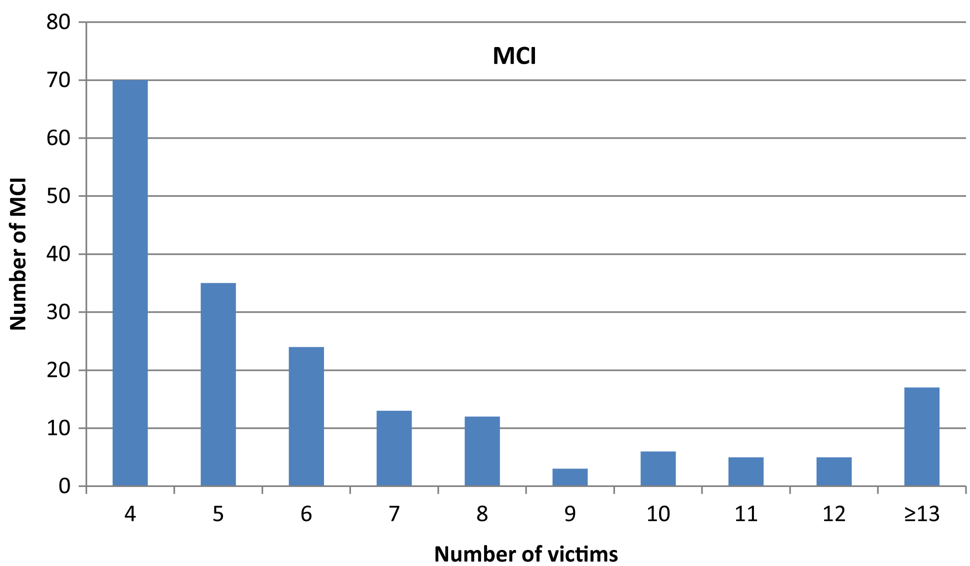

Figure 2. Frequency of victims per MCI.

significantly ($P < 0.05$) more moderate-injured patients (yellow) and fires and intoxications were below the average. MCI related with fires had significantly ($P < 0.05$) less severe-injured victims. A total of 37 (2.8%) patients died during an MCI on this period; fires had significantly ($P < 0.05$) less deaths and sea-related incidents had significantly ($P < 0.05$) more deaths. The incidents with the higher number of victims were 1 traffic accident and 2 fires, with 45, 35, and 27 victims respectively. The incidents with more deaths were 2 shipwrecks and 1 traffic accident, with 7, 5, and 4 deceased.

Figure 2 shows the distribution of average victims per MCI. Incidents involving 4 victims represented 37.7% of all MCI and 5 victims MCI 18.8%. A total of 96 incidents (37.9%) had between 5 and 8 victims. The 2 incidents with more victims had 45 and 35 respectively, and both were road traffic incidents.

Figure 3 shows the distribution of the frequency of MCI by month along the year. A monthly average of 2.9 MCI (SE = 0.35; ESM = 15.90) have occurred in the studied regions in the period 2014 - 2020. There is a significant ($P < 0.05$) increasing of frequency of incidents in the months of January and July, both months had more than 30 incidents each 1 during the entire time of data collection. On the other hand, it was found a significant ($P < 0.05$) reduction of MCI through the months of April and June. Regression analysis has shown no significant trend in the evolution of the monthly frequency of MCI throughout the year.

Weekly day tendencies of MCI frequency are shown in Figure 4. Of all MCI, 18.6% occurred on Sunday and 9 to 16% on other days of the week.

Occurrence of MCI during a 24-hour period is shown in Figure 5. There was an increase in MCI frequency around 2 periods of the day, in the afternoon and the night, but this increase was not of statistically significant. MCIs from 13:00 to 23:00 gathered 71.9% of all MCIs. Of the total of traffic accidents, 56.4% occurred between 15:00 and 21:00. There is a no significant reduction of MCIs during the evening and before midday. Regarding distribution of traffic accident, there was a significant ($P < 0.05$) increasing of MCI at 21:00.

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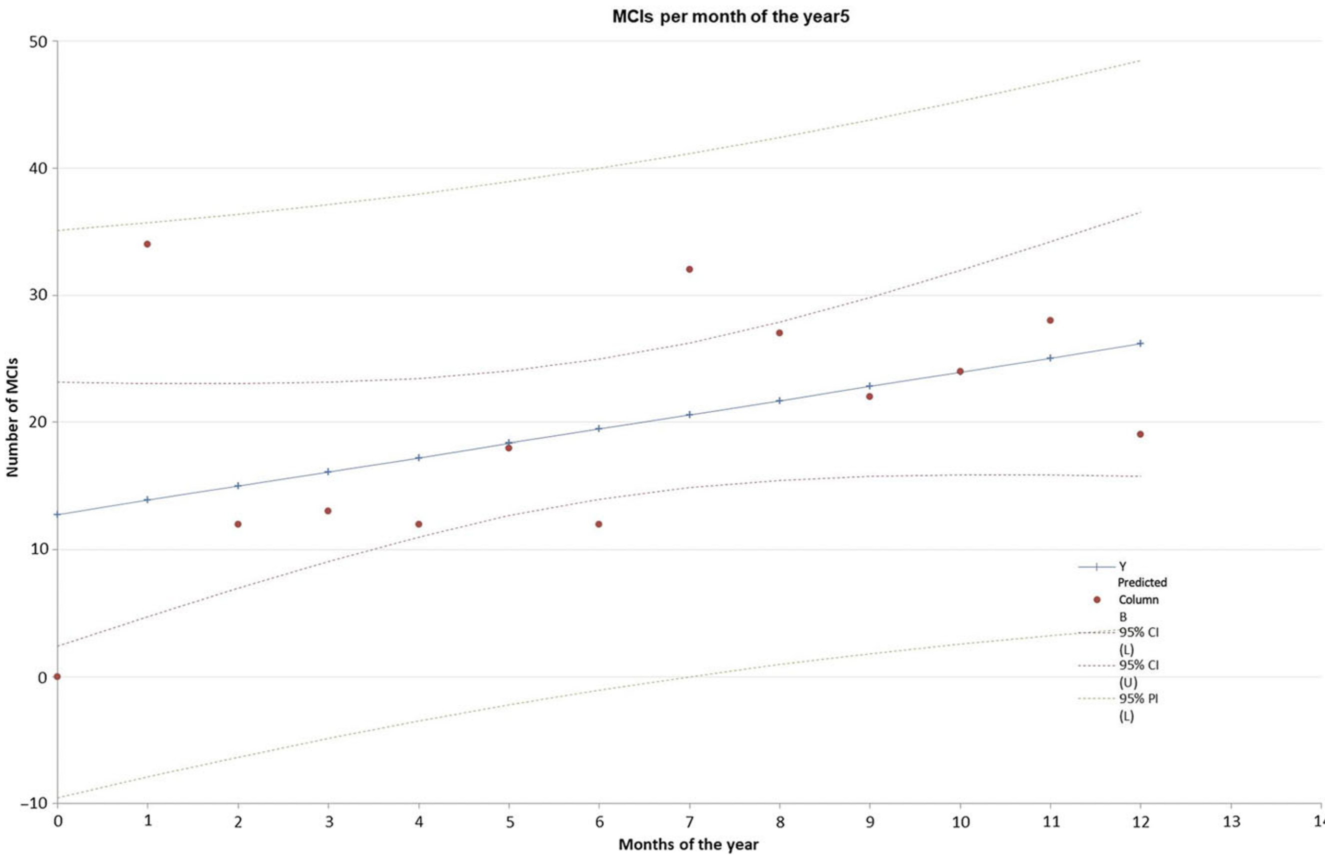

Figure 3. Regression analysis of MCI per month of the year.

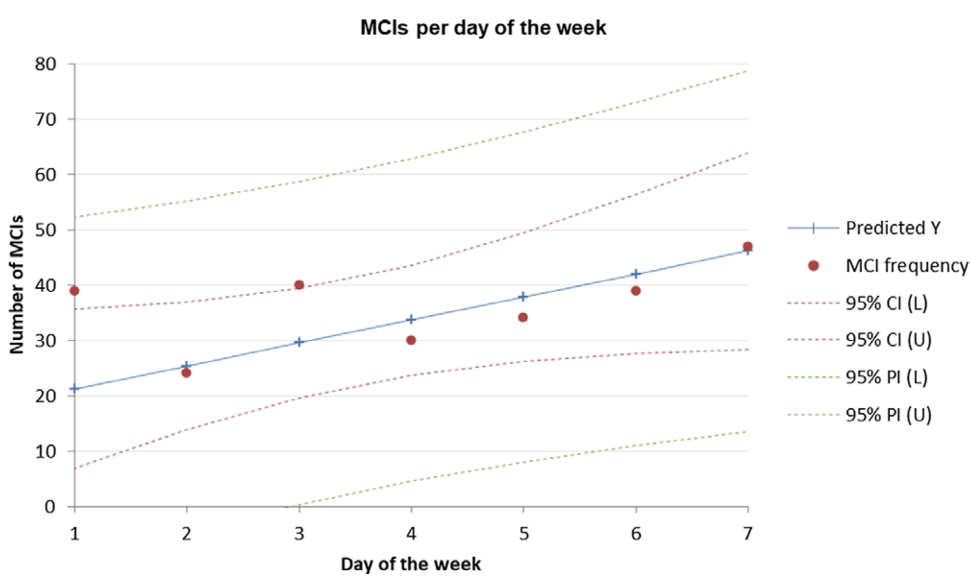

Figure 4. Frequency of MCIs per day of the week, where 1 represents the first day of the week (Monday) following the respective order.

Discussion

A standardized concept of MCI is still lacking 7 years after the publication of the last study which analyzed the MCI of a specific region of Spain. Efforts have been made in order to centralize the data collected for every MCI, as a result it was possible to gather the MCI's information of 5 different autonomous communities in Spain, looking forward to scale-up the system to the entire country.

During this period de incidence rate of MCI was 0.36 per 100000 inhabitants per year. Compared with other studies,

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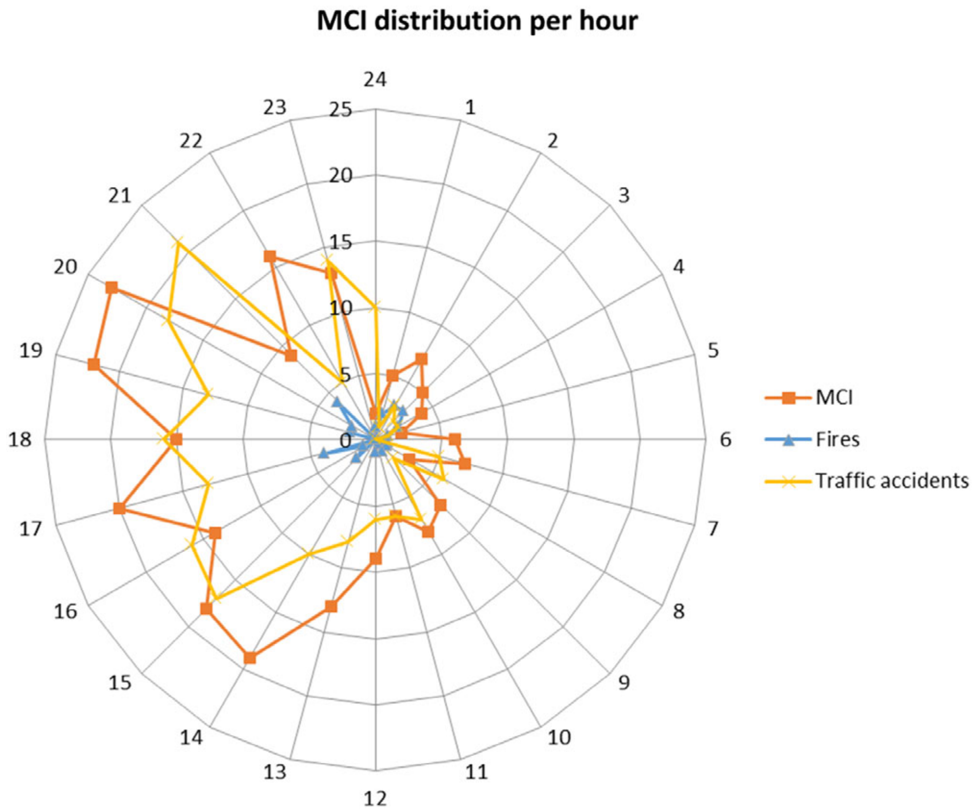

Figure 5. MCI distribution per hour of the day. Included the 2 most frequent type of incident (Traffic accidents and fires).

Helsinki (Finland) reported 1.8/100000, Western Cape Province (South Africa) registered 13.1/100000,[15,16] but these numbers are influenced by the definition criteria used for MCI by each research author. In addition, we could expect an existing relation between the emergency infrastructure and the specific conditions (social, environmental, structural) of each region studied.

The most common type of MCIs were those related to motor vehicles on roads (79.8%); they lead the list in USA (62.7%), South Korea (75.7%) and Western Cape (94.0%). In contrast, the second most frequent type of MCI was different; in USA it was catalogued as 'Other' which included water transport crashes, smoke inhalation, etc., (10.3%), South Korea registered industrial incident as a second cause of MCI (10.4%), residential fire occupied the second place in Helsinki (Finland) (15.2%), and chemical incidents in Western Cape (South Africa) (1.5%).[15–18] It is important to note that traffic accidents are by far the most frequent type MCI, more than any other. This is an issue of special concern of public health, as we will see when we discuss the mortality rate of each type of MCI. This is an important aspect to bear in mind when stablishing specific training programs, which should focus on the epidemiology of MCI in each region, and to decide the appropriate material and their allocation, to improve preparation and response to MCI. Also, results coming from analyzing MCI can help to validate previous risk assessment studies, most of them based on hypothesis which need to be confirmed thanks to MCI and disasters databases.

Most MCI were concentrated in the afternoon, between 14:00 and 20:00 hours. Given that traffic accidents are the leading cause of MCIs, it is expected to find more accidents when the roads are busy. In comparison to other studies, it was found that the same pattern occurred in USA which recorded 38.1% of the MCIs between 15:00 and 21:00.[17] Meanwhile, in Western Cape (South Africa) there were 2 hourly peaks of MCIs observed from 04:00 to 08:00 and 16:00 to 20:00, both periods accumulated 39.3% of the MCIs.[15]

The distribution of patients according to their triage categorization varied. Traffic accidents caused 64% minor injured victims (green) and had a lethality of 2% (black). Residential fires had mostly minor injured outcomes (80%) and only 1 death (which represents 0.3%). In comparison, nautical incidents were related to a high lethality of 40%, probably related to the difficult of emergency response, which will be discussed below. In Western Cape (South Africa) most patients were also catalogued as minor injured (54.6%) and the percentage of deaths was 4.4%.[15] Analyzing severity of patients according to each type of MCI may help us to decide resources activation, as many mild patients may have an impact on transport logistics, but more severe patients have an impact on prehospital medical care and evacuation. Establishing the MCI profile of specific regions is an important aspect to be part of the risk analysis stages.

The average response for road traffic incidents was 31.32 minutes, the response in residential fires was 26.36 minutes and sea-related accidents had the higher time of response of 37.75 ($P < 0,05$), probably related to the difficult accessibility of emergency units to the event. In Helsinki (Finland), the average response to traffic incidents was 7.6 minutes, and residential fires were reached in 9.7 minutes.[14] It is important to note that the territory evaluated in this study covers a large area with low population density, therefore the emergency system must cover a bigger area, compared to an urban area, with high population density like Helsinki.[11]

It is important to note that the different definitions used for MCI could limit the approach to a standardized MCI data collection. The actual concept proposed by WHO is more likely to reflect the lack of a well-established emergency response systems, but it doesn't assess the severity of the MCI.[1] A motor vehicle accident in a rural area will be catalogued as MCI if there are not enough emergency units, but in an urban area with the same amount of victims and enough emergency units it won't be catalogued as an MCI. If we analyze the consequences of this concept, low-income countries will tend to have more MCIs than high income countries, just because of the emergency infrastructure. These discrepancies could give a bias even though the same number of incidences happen in different regions.

As a conclusion, road traffic accidents are the most frequent MCI, followed by fires or explosions. Minor injuries predominate, with high rescue medicalization needs in traffic accidents. More than half of MCI have 5 or less patients. Fires had significantly more minor-injured patients but had a significantly greater number of units deployed, and sea-related incidents had significantly more fatal victims. MCI are more frequent in January, July, on Sundays, and during afternoon and night periods. Sea-related incidences had a minor significant incident duration, and intoxications, fires and others had a significant longer duration. Analyzing MCI allows us to improve our knowledge and have more data to plan according to MCI profiles.

Data availability statement. The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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Authors contributions. All authors made substantial contributions to conception and design, acquisition of data, or analysis and interpretation of data; took part in drafting the article or revising it critically for important intellectual content; agreed to submit to the current journal; gave final approval of the version to be published; and agreed to be accountable for all aspects of the work.

Pedro Arcos Gonzalez designed the study, defined data, analyzed data, drafted the manuscript, and wrote and approved the final manuscript; Carlos Adrian Vargas Campos analyzed data, drafted the manuscript, and approved the final manuscript; José Antonio Cernuda Martinez analyzed data, drafted the manuscript, and approved the final manuscript, Cecilia Naves Gomez defined data, collected data, drafted the manuscript, and approved the final manuscript; Ignacio Villellas Aguilar collected data, drafted manuscript, and approved the final manuscript; Begoña Lea Castro collected data, drafted the manuscript, and approved the final manuscript; Marta Dorribo Masid collected data, drafted the manuscript, and approved the final manuscript; Emilio Domínguez Sanchez collected data, drafted the manuscript, and approved the final manuscript; Rafael Castro Delgado designed the study, defined the data, analyzed the data, drafted the manuscript, and wrote and approved the final manuscript.

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