Incidence and Mortality Rates of Disasters and Mass Casualty Incidents in Korea: A Population-Based Cross-Sectional Study, 2000-2009

The objective of study was to evaluate the incidence and mortality rates of disasters and mass casualty incidents (MCIs) over the past 10 yr in the administrative system of Korea administrative system and to examine their relationship with population characteristics. This was a population-based cross-sectional study. We calculated the nationwide incidence, as well as the crude mortality and injury incidence rates, of disasters and MCIs. The data were collected from the administrative database of the National Emergency Management Agency (NEMA) and from provincial fire departments from January 2000 to December 2009. A total of 47,169 events were collected from the NEMA administrative database. Of these events, 115 and 3,079 cases were defined as disasters and MCIs that occurred in Korea, respectively. The incidence of technical disasters/MCs was approximately 12.7 times greater than that of natural disasters/MCs. Over the past 10 yr, the crude mortality rates for disasters and MCIs were 2.36 deaths per 100,000 persons and 6.78 deaths per 100,000 persons, respectively. The crude injury incidence rates for disasters and MCIs were 25.47 injuries per 100,000 persons and 152 injuries per 100,000 persons, respectively. The incidence and mortality of disasters/MCs in Korea seem to be low compared to that of trend around the world.

Key Words: Disasters; Mass Casualty Incidents (MCIs); Epidemiology

INTRODUCTION

Disasters can be defined as rapid or emerging incidents that require excessive resources, or more resources than are available in a local area when natural or technical dangers are present (1-4). The term mass casualty incident (MCI) refers to disasters that involve many people (5, 6). MCIs occur in many different contexts, including car crashes, chemical leaks, building collapses, fires, terrorism events, and mass gatherings (7, 8).

The frequency of disasters and MCIs is increasing, and calamities always involve mass casualties because they are unpredictable. From 1994 to 2005, according to a UN report, the world witnessed over 67,000 deaths and 260 million people wounded each year due to disasters (9). An estimated loss of US$204 billion occurred due to natural disasters in the 1980s (10, 11). Disasters and MCIs consume local resources in the short and long term, and therefore, appropriate preparation is required to avoid high death and failure rates in such cases (7, 8).

Disaster and MCI-related research in Korea has mostly focused on the establishment of a national disaster management system (12), the role of disaster management agencies (13), database (DB) building for disaster prevention (14), and descriptive studies on post-disaster stress management (15), post-traumatic stress disorder (PTSD) (16), hospital disaster (17), incidents at mass gatherings and sporting events and building collapses (18, 19). According to statistics report over the 1990’s (1991-2000), natural disasters/MCs such as storms and floods have caused an annual average of 122 people dead or missing, 17,219 refugees and property losses of over 580 billion won (KRW) (20). In the same period technical disasters/MCs such as train derailments, plane crashes, bridge collapses, fires aboard liners, city gas explosions and building collapses cause tens to...
South Korea covers an area of approximately 99,720 km² and has a population of just over 48 million people. Korea, based on Act No. 7188 (March 11, 2004) the framework act on the management of disaster and safety, adopts mixed model between civil defence model and emergency medical treatment priority system as disaster policy, in which administration security department carries out a key role (22). Disaster management system of Korea consists of the central safety management committee, headed by the prime minister and subcommittees headed by the ministers of various government ministries. The central safety management committee supervises and coordinates overall policy related to disaster and safety, and also promotes negotiations and coordination among the relevant ministries. The subcommittees help ensure the seamless operation of the central committee, especially, the coordination committee under the Minister of Public Administration and Security, is in charge of the overall process of negotiations and coordination with regard to tasks delegated by the central committee. The National Emergency Management Agency (NEMA) provides emergency medical service (EMS) to Korea and plays a key role in the response to disasters and MCIs in most communities. A single-tiered fire-based EMS handles disasters and MCIs occurring throughout the entire Korean region and includes 16 regional headquarters of the fire department with a total of 1,400 advanced ambulances and 5,400 EMS providers. In addition, headed by the administrator of the NEMA, operates the central emergency rescue control team to supervise and control matters related to emergency rescue, command, and control at the disaster site.

**Study settings**

South Korea covers an area of approximately 99,720 km² and has a population of just over 48 million people. Korea, based on Act No. 7188 (March 11, 2004) the framework act on the management of disaster and safety, adopts mixed model between civil defence model and emergency medical treatment priority system as disaster policy, in which administration security department carries out a key role (22). Disaster management system of Korea consists of the central safety management committee, headed by the prime minister and subcommittees headed by the ministers of various government ministries. The central safety management committee supervises and coordinates overall policy related to disaster and safety, and also promotes negotiations and coordination among the relevant ministries. The subcommittees help ensure the seamless operation of the central committee, especially, the coordination committee under the Minister of Public Administration and Security, is in charge of the overall process of negotiations and coordination with regard to tasks delegated by the central committee. The National Emergency Management Agency (NEMA) provides emergency medical service (EMS) to Korea and plays a key role in the response to disasters and MCIs in most communities. A single-tiered fire-based EMS handles disasters and MCIs occurring throughout the entire Korean region and includes 16 regional headquarters of the fire department with a total of 1,400 advanced ambulances and 5,400 EMS providers. In addition, headed by the administrator of the NEMA, operates the central emergency rescue control team to supervise and control matters related to emergency rescue, command, and control at the disaster site.

**Study objectives**

We aimed to calculate the incidence, mortality and overall rates of disasters and MCIs and to examine their relationship with population characteristics, using health-related indicators based on disaster/MCI database of NEMA to facilitate future comparison of disasters and MCIs between domestic and foreign cases.
cludes daily incidents, and is sorted by severity. The ‘Daily Accidental Management Situation Report’ can be downloaded from the home page of NEMA (www.nema.go.kr) and is prepared by the NEMA Disaster Status Control Center. Next, we collected and analyzed internal NEMA reports, referred to as ‘Accidental Status Reports’, which notify the relevant teams within NEMA (e.g., fire investigation, rescue and EMS) about major incidents (Appendix 1-4). These reports were made available for this study through the cooperation of NEMA. Using the Daily Accidental Management Situation Reports, all NEMA disaster reports from the 16 Korean provinces were coded and entered into an electronic database. Using the Accidental Status Reports, more detailed information was coded and added to this database. Finally, the cases that met the defined category of disasters and MCIs for this study were extracted to establish the final dataset.

The final dataset for this study is the result of the reconstructed database of reports from 16 regional fire department headquarters within NEMA from January 2000 to December 2009. The extracted variables were the dates of the disaster, the address, the disaster type, the number of casualties, the estimated financial loss, the mobilized manpower, the victims’ gender, age and major symptoms, the location of the fire (if the event was a fire), the type of collision (if the event was a car crash), and the number of mobilized ambulances (Table 1).

**Statistical analysis**

SAS version 9.1 was used as the statistical analysis tool. The primary outcome was analyzed using a descriptive analysis to calculate the incidence, crude mortality rates and crude injury incidence rates of disasters and MCIs for each year, using central populations from the Ministry of Statistics. The secondary outcome was the assessment of the incidence trends of disasters/

| Group                        | Extracted variables                                      |
|------------------------------|-----------------------------------------------------------|
| Incident occurrence related  | - Disaster identification number                           |
|                              | - Date/time of the incident                               |
|                              | - Address of the incident                                 |
|                              | - Mechanism of the incident                               |
|                              | - Cost of damage                                           |
|                              | - Mobilized manpower                                      |
|                              | - *Loss area                                               |
|                              | - Location of incident                                     |
| Related casualties           | - Number of deaths                                         |
|                              | - Death, missing                                           |
|                              | - Number of injured persons                               |
|                              | - Injury, severity, minority                               |
|                              | - Transportation                                          |
|                              | - *Name, *age, *sex                                       |
|                              | - Injury severity                                          |
| Medical resources used       | - Number of ambulances                                     |
|                              | - *Transportation to hospitals of casualties               |
|                              | - Re-transportation status                                 |

*Extracted variables from disaster status reports.

MCIs by time-series and by type and calculation of the number of deaths and casualties by disaster/MCI type, the number of deaths and crude death rates by province, and the number of injuries and crude injury incidence rates by province.

**RESULTS**

We collected 43,169 events from the NEMA administrative database, covering the period from January 2000 to December 2009. Of these, 115 and 3,079 were defined, respectively, as disasters and MCIs that occurred in Korea. There were 2,286 (72.3%) cases of disasters and MCIs in rural areas, which is approximately 2.6 times greater than the 879 (27.7%) cases that occurred in urban areas. The incidence of technical disasters/MCIs was approximately 12.7 times greater than that of natural disasters/MCIs (2,960 cases vs 233 cases). With regard to both disasters and MCIs, transportation crashes were the most common cases. In an analysis of the seasonal factors, both disasters and MCIs occurred more frequently in the summer (June-August) and the winter (November-February). With respect to the provincial factor, the Gyeonggi province showed the highest frequency of disasters (27 cases, 23.5%) and MCIs (606 cases, 19.7%), followed by Seoul with 17 cases (14.8%) of disasters and 343 cases of MCIs (11.1%) and Gyeongnam with 5 cases (4.4%) of disasters and 269 cases of MCIs (8.7%) (Table 2).

From 2000 to 2009, both disasters and MCIs showed a tendency to increase in number over time, but there is no significant time trend, although the frequency of incidents and the number of casualties were directly proportional in MCIs (Fig. 1, 2).

As for natural factors, general floods were the most common type of disaster and MCI with 125 cases (61.0%), followed by flash floods with 47 cases (20.2%) and tropical cyclones with 24 cases (10.3%). The number and the frequency of injuries and deaths were on the same order. For disasters only, general floods were the most common type (17 cases, 68.4%), followed by tropical cyclones (4 cases, 15.4%) and flash floods (3 cases, 11.5%). The number and frequency of injuries and deaths were on the same order. For MCIs, the number and frequency of occurrence and the number of injuries and deaths were the same as those of the total (Table 3).

As for technical factors, road crashes were the most common type of disaster and MCI with 2,326 cases (78.6%), followed by fire with 221 cases (7.5%) and others incidents such as isolation of closed space, escalator incident, rippling incident, leisure place incident with 166 cases (5.6%). The number and the frequency of affected and deaths were on the different order for disaster and MCI. For affected victims of disaster only, road crashes were the most common type (2,369 persons, 48.3%), followed by mass gatherings (1,499 persons, 24.9%), fires (991 persons, 16.5%). For dead victims of disaster, fires were most common type (258 persons, 35.9%), followed by road crashes.
Incidence of Disasters and Mass Casualty Incidents in Korea

Demographic findings of disaster and MCI incidence in Korea: 2000-2009
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The crude injury incidence rates per 100,000 people were 2.36 per 100,000 people and 6.78 per 100,000 people, respectively. The crude mortality rates for disasters and MCIs nationwide were 3.6%, followed by fires (3.6%), etc. For MCIs, the number and frequency of occurrences were 13.7%, water crashes (75 persons, 4.9%), and collapse (55 persons, 3.6%), etc. For MCIs, the number and frequency of occurrence and the number of injuries and deaths were the same as those of the total (Table 4).

The crude mortality rates for disasters and MCIs nationwide were 2.36 per 100,000 people and 6.78 per 100,000 people, respectively. The crude injury incidence rates per 100,000 people for disasters and MCIs nationwide were 25.47 and 152, respectively (Table 5). For disasters by province, Ulsan showed the highest injury incidence rate (11.15 per 100,000), followed by Jeonnam (7.67) and Gangwon (7.09). For MCIs, the rate for Gangwon was 23.34 per 100,000 people, followed by Jeju (18.5) and Jeonnam (17.4).

DISCUSSION

Most research undertaken in the early and mid-20th century focused on the definition of disaster, epidemiologic studies and research methodology. Subsequent research by the World Health Organization (WHO) and CRED was mostly focused on natural disasters, such as earthquakes, floods, high winds, tornados, and heat waves, comparing the causes of disasters between countries and continents and measuring the economic losses, mortality, injuries and suffering incurred by these events (3, 4, 8, 25, 26). Spain showed a linear increase in the incidence of disasters over a 55-yr period (1950-2005), 82% of which were natural and 18% technical (2). Most disasters showed a mixed pattern. For disaster types, flood was the most common (31.5%),

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followed by air crashes (30.2%). With regard to the effects of technical disasters, transit crashes showed the highest death rates (71.6%). For transit crashes, land-based events were the most common (43.6%), followed by air (32.1%) and sea (24.4%), results that were significantly different from those of Korea. In Britain, major incidents documented in research papers over a 28-yr period were analyzed to calculate the incidence rate; the results indicated a rate of 3 to 4 incidents per year with a total of 108 incidents (range 0-10) (2,8). There were 63 cases (59.2%) of public transportation crashes, 22 cases of civil disturbance (20.3%), and 16 cases of industrial incidents (14.8%). These results were similar to those for MCI in our study.

In our study, disasters and MCIs were analyzed to calculate the national and regional statistics for the incidence, crude mortality, crude injury, and characteristics of each disaster type using the NEMA database, which includes all major incidents and accidents, to increase the credibility and sensitivity of the study. Furthermore, in our study, both disasters and MCIs were analyzed from NEMA reports to verify the special characteristics of disasters and decreases the selection bias. We reconstructed our database ing the NEMA database, which includes all major incidents and decreased the selection bias. We reconstructed our database.

Table 3. Incidence of events and victims of natural disaster and MCI by type: 2000-2009

| Group          | Main-type       | Sub-type   | Total Events | Affected* | Dead | Disaster Events | Affected* | Dead | MCI Events | Affected* | Dead |
|----------------|-----------------|------------|--------------|-----------|------|-----------------|-----------|------|------------|-----------|------|
| Geophysical    | Earthquake      | Tsunami    | 1 (0.4)      | 0 (0.0)   | 0 (0.0) | 1 (0.5)         | 0 (0.0)   | 0 (0.0) | 1 (0.5)    | 0 (0.0)   | 0 (0.0) |
|                | Mass movement   | Landslide  | 1 (0.4)      | 0 (0.0)   | 0 (0.0) | 1 (0.5)         | 0 (0.0)   | 0 (0.0) | 1 (0.5)    | 0 (0.0)   | 0 (0.0) |
| Meteorological | Storm           | Local storm| 2 (2.2)      | 0 (0.0)   | 0 (0.0) | 2 (2.4)         | 0 (0.0)   | 0 (0.0) | 2 (2.4)    | 0 (0.0)   | 0 (0.0) |
| Climatological | Extreme         | Heat wave  | 1 (0.4)      | 0 (0.0)   | 0 (0.0) | 1 (0.5)         | 0 (0.0)   | 0 (0.0) | 1 (0.5)    | 0 (0.0)   | 0 (0.0) |
|                | temperature     | Heavy snow | 1 (3.3)      | 0 (0.0)   | 0 (0.0) | 2 (1.0)         | 0 (0.0)   | 0 (0.0) | 2 (1.0)    | 0 (0.0)   | 0 (0.0) |
|                | Wild fires      | Wild fires | 2 (0.1)      | 0 (0.0)   | 0 (0.0) | 2 (1.0)         | 0 (0.0)   | 0 (0.0) | 2 (1.0)    | 0 (0.0)   | 0 (0.0) |
| Hydrological   | Flood           | General flood | 125 (61.9) | 71 (41.3) | 124 (74.9) | 108 (52.2) | 55 (40.2) | 100 (53.2) | 44 (23.1) | 67 (32.7) |
|                | Storm           | Storm surge | 1 (0.4)      | 0 (0.0)   | 0 (0.0) | 1 (0.5)         | 0 (0.0)   | 0 (0.0) | 1 (0.5)    | 0 (0.0)   | 0 (0.0) |
| Biological     | Epidemic        | Bacterial | 13 (5.6)     | 1 (0.2)   | 0 (0.0) | 12 (5.8)        | 194 (6.9) | 1 (0.6) | 16 (7.6)   | 4 (1.8)   | 0 (0.0) |
|                |                 | Others     | 9 (3.4)      | 0 (0.0)   | 0 (0.0) | 9 (4.4)         | 140 (5.0) | 0 (0.0) | 9 (4.4)    | 140 (5.0) | 0 (0.0) |

*Affected victims include population who is injured, missed, displaced and dead. MCI, Mass casualty incident.

Table 4. Incidence of events and victims of technical disaster and MCI by type: 2000-2009

| Group          | Main-type       | Sub-type   | Total Events | Affected* | Dead | Disaster Events | Affected* | Dead | MCI Events | Affected* | Dead |
|----------------|-----------------|------------|--------------|-----------|------|-----------------|-----------|------|------------|-----------|------|
| Industrial     | Fire            | Fire       | 221 (7.5)    | 14 (15.7) | 91 (41.7) | 207 (7.2)       | 2,361 (6.7) | 211 (13.7) | 72 (4.4)   | 3,062 (10.3) | 34 (3.2) |
|                | Collapse        | Collapse   | 40 (1.4)     | 0 (0.0)   | 0 (0.0) | 40 (1.4)        | 417 (12.1) | 55 (3.6)   | 14 (2.7)   | 476 (15.3)  | 57 (3.3) |
|                | Explosion       | Explosion  | 75 (2.5)     | 2 (2.3)   | 101 (41.7) | 73 (2.5)        | 827 (22.0) | 92 (4.1)   | 726 (26.2) | 726 (23.0)  | 51 (3.3) |
| Transport      | Road crash      | Road crash | 2,326 (78.8) | 43 (48.3) | 2,369 (93.9) | 2,283 (79.5)  | 28,479 (79.9) | 1,072 (69.7) | 24 (2.7)   | 2,361 (6.7)  | 211 (13.7) |
|                | Rail crash      | Rail crash | 9 (0.3)      | 0 (0.0)   | 0 (0.0) | 8 (0.3)         | 261 (7.8)  | 10 (0.5)   | 150 (5.8)  | 141 (4.4)   | 8 (0.5)  |
|                | Air crash       | Air crash  | 6 (0.2)      | 0 (0.0)   | 0 (0.0) | 5 (0.2)         | 358 (9.9)  | 136 (6.0)  | 65 (2.2)   | 473 (16.2)  | 9 (0.6)  |
|                | Water crash     | Water crash | 37 (1.3)     | 3 (3.4)   | 40 (13.7) | 34 (1.2)        | 463 (13.1) | 112 (4.0)  | 423 (13.2) | 75 (4.9)    | 75 (4.9) |
| Hazardous      | Chemical        | Chemical   | 11 (0.4)     | 2 (2.3)   | 129 (21.2) | 9 (0.3)         | 235 (6.6)  | 1 (0.1)    | 110 (3.3)  | 0 (0.0)     | 1 (0.1)  |
|                | accident        | accident   | 0 (0.0)      | 0 (0.0)   | 0 (0.0) | 0 (0.0)         | 0 (0.0)    | 0 (0.0)    | 0 (0.0)    | 0 (0.0)     | 0 (0.0)  |

*Affected victims include population who is injured, missed, displaced and dead. MCI, Mass casualty incident.
crashes, general floods, incidents at mass gatherings, and fires. The leading causes for MCIs were road crashes, fires, and general floods.

NEMA has two separate lines of work, fire-based tasks and mitigation-based tasks, and it focuses only on prevention, rapid response and mitigation to minimize disaster damage with a minimum expenditure of resources. Thus, there is no efficient connection and cooperation with the Ministry of Health and Welfare, which handles the public health sector. A disaster management plan for public health is warranted to properly analyze and present the characteristics of disasters/MCIs, thus enabling preparations for each region, mitigating damages, and monitoring trends in disasters/MCIs. NEMA and the Ministry of Health and Welfare need to establish a system for cooperation on disaster management and epidemiologic investigation of the disasters/MCIs using a predetermined standard.

In this regard, this study may have significant value if it is used to compare domestic cases with those in foreign countries. Furthermore, a set of standards needs to be established for epidemiologic research on disasters/MCIs, along with a web-based registry system to maintain and update research results and a monitoring system for measuring the impact of disasters/MCIs. Finally, administrative data were duplicated or may have been overlooked because when the incident occurred on the boundary of two provinces, such data could not be analyzed. Third, some of the administrative data were underreported due to the characteristics of the administrative data. The cause-effect relationship between disasters/MCIs and the environment to risks could not be determined, and thus, this result could not be analyzed. Fourth, the data source used in this study was the administrative data prepared for immediate disaster management, but the number of incidents and casualties may have been underestimated. In addition, the data reported to NEMA for early and mid-2000 did not contain data on MCIs and biologic disasters such as severe acute respiratory syndrome (SARS) and avian influenza, which may have contributed to an underestimation of the number of incidents.

Table 5. Deaths, injuries and mortality rates of disaster and MCI by locality: Nationwide in South Korea, 2000-2009

| Locality | Population* (unit: 1,000 persons) | Population Density* (unit: persons/ km²) | Area* (unit: km²) | No. of injuries (unit: persons) | Injury incidence rates (unit: persons) | No. of deaths (unit: persons) | Crude mortality rates (unit: 100,000 persons) | No. of affected (unit: persons) |
|----------|---------------------------------|---------------------------------|----------------|----------------------------|---------------------------------|--------------------------|---------------------------------|----------------------------|
| Seoul    | 10,057                          | 16,614                          | 605             | 1,266                      | 3,959                           | 1.84                     | 3.95                            | 14 104                      |
| Pusan    | 3,602                           | 4,722                           | 763             | 68                         | 2,145                           | 0.88                     | 6.01                            | 24 79                       |
| Daegu    | 2,487                           | 2,810                           | 885             | 306                        | 668                             | 6.05                     | 2.68                            | 201 29                      |
| Incheon  | 2,584                           | 2,596                           | 996             | 110                        | 1,417                           | 2.13                     | 5.43                            | 1 28                        |
| Gwangju  | 1,416                           | 2,824                           | 501             | 0                          | 376                             | 0.26                     | 0.61                            | 0 13                        |
| Daejeon  | 1,452                           | 2,689                           | 540             | 59                         | 591                             | 0.06                     | 0.02                            | 0 07                        |
| Ulsan    | 1,063                           | 1,005                           | 1,057           | 236                        | 951                             | 11.15                    | 8.90                            | 90 27                       |
| Gyeonggi | 10,297                          | 1,016                           | 10,136          | 1,992                      | 7,413                           | 2.06                     | 7.02                            | 107 289                     |
| Gangwon  | 1,484                           | 89                              | 16,593          | 635                        | 3,471                           | 7.09                     | 23.34                           | 29 170                      |
| Chungbuk | 1,488                           | 200                             | 7,433           | 77                         | 1,662                           | 2.59                     | 11.17                           | 14 53                       |
| Chungnam | 1,915                           | 223                             | 8,608           | 219                        | 2,311                           | 3.79                     | 12.05                           | 15 189                      |
| Jeonbuk  | 1,826                           | 227                             | 8,056           | 750                        | 1,760                           | 5.84                     | 9.60                            | 75 107                      |
| Jeonnam  | 1,899                           | 157                             | 12,110          | 697                        | 3,237                           | 7.67                     | 17.40                           | 35 150                      |
| Gyeongbuk| 2,690                           | 142                             | 19,027          | 683                        | 2,728                           | 4.22                     | 10.24                           | 81 179                      |
| Gyeongnam| 3,087                           | 294                             | 10,524          | 343                        | 2,819                           | 2.77                     | 9.09                            | 146 173                     |
| Jeju     | 535                             | 290                             | 1,848           | 4                          | 1,001                           | 0.37                     | 18.50                           | 26 56                       |
| Unknown  | 0                               | 0                               | 0               | 0                          | 5                               | 0.25                     | 0                               | 0 0                        |
| Total    | 47,878                          | 481                             | 99,679          | 7,450                      | 36,761                          | 25.47                    | 152.0                           | 1,131 1,708                 |

*Population, population density and area were based on the information from the statistics Korea website [http://kosis.kr/feature/feature_O102List.jsp?meneulid=all&nodei=1021, [accessed 15 April 2012]]. †Unknown data of locality event occurred boarder lines of each province.
floods, and mass gathering incidents. For MCIs, the most common types were road crashes, fires, and general floods. Floods and technical disasters/ MCIs, respectively. The crude death rates per 100,000 people for disasters and MCIs were 2.36 and 6.78, respectively. The crude injury incidence rates per 100,000 people for disasters and MCIs were 35.47 and 152, respectively.

We established a nation-wide administrative EMS-reported disaster and MCI database that includes 10 yr of data. The incidence and mortality of disasters/MCIs in Korea seem to be lower compared to that of trend around the world. These data can be used to determine the optimal response plan for disaster and MCIs in Korea. Further study will be needed for disaster and MCI data base computerization to monitor incidents and to establish preparedness and early warning systems.

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DISCLOSURE

The authors have no conflicts of interest to disclose.

REFERENCES

1. Smith E, Wasiak J, Sen A, Archer F, Burkle FM Jr. Three decades of disasters: a review of disaster-specific literature from 1977-2009. Prehosp Disaster Med 2009; 24: 306-11.
2. Arcos González P, Pérez-Berrocal Alonso J, Castro Delgado R, Cadaveco González B. Trends in disasters in Spain and their impact on public health: 1950-2005. Public Health 2007; 121: 375-7.
3. Twum-Danso NY. Disaster epidemiology: prudent public health practice in the Pacific Islands. Pac Health Dialog 2002; 9: 58-63.
4. Dominici F, Levy JI, Louis TA. Methodological challenges and contributions in disaster epidemiology. Epidem Rev 2005; 27: 9-12.
5. De Boer J. Definition and classification of disasters: introduction of a disaster severity scale. J Emerg Med 1989; 8: 591-5.
6. Rutherford WH, de Boer J. The definition and classification of disasters. Injury 1983; 15: 10-2.
7. Kuisma M, Hiltunen T, Määtä T, Puolakka J, Boyd J, Nousiila-Wik M, Hakala T. Analysis of multiple casualty incidents - a prospective cohort study. Acta Anaesthesiol Scand 2005; 49: 1527-33.
8. Carley S, Mackway-Jones K, Donnan S. Major incidents in Britain over the past 28 years: the case for the centralised reporting of major incidents. J Epidemiol Community Health 1996; 52: 392-8.
9. Societies IFoRCatRC. World disaster report: International Federation of the Red Cross and the Red Crescent Societies: 2001–2004. Available at http://www.ifrc.org/en/publications-and-reports/world-disasters-report [accessed on 7 January 2013].
10. Centre for Research on the Epidemiology of Disasters. Annual statistical review: numbers and trends 2010 CRED. Brussels 2011. Available at http://www.cred.be/publications [accessed on 4 January 2011].
11. De Boer J. Order in chaos: modelling medical management in disasters. Eur J Emerg Med 1999; 6: 141-8.
12. Park CS. An information fusion-based disaster information system framework. J Korean Soc Disaster Inf 2009; 5: 40-8.
13. Choi NY, Chae WH. Building the governance system for the effective disaster management of local government: focusing Buchon City. Korean Policy Sci Rev 2008; 12: 227-54.
14. Lee CY, Kim TH, Cha SY. A study of the extraction algorithm of the disaster sign data from web. J Korean Soc Disaster Inf 2011; 7: 139-49.
15. Kim KH, Kwon SJ. Posttraumatic stress responses of Taean residents: focused on a regional comparison at two and eight months after the disaster. ECO 2009; 13: 89-125.
16. Han JE, Jung SD, Kim GE. Crisis intervention models: a comparison of six models for improving mental health of disaster victims. Korean Rev Crisis Emerg Manage 2011; 7: 49-70.
17. Back MH, Kim HJ. Analysis of hospital disaster in South Korea from 1990 to 2008. Yonsei Med J 2010; 51: 965-70.
18. Wang SI, Byun HJ. A survey of Human Injury and Crowded Packing in Mass Gathering. J Korean Soc Disaster Inf 2011; 7: 12-20.
19. You KC, Ahn ME, Cho YJ, Chaeng JM, Lim KS. Injury type in Sampung collapse. J Korean Soc Emerg Med 1997; 8: 185-92.
20. National Emergency Management Agency. An annual report of disaster, 1985-2000. 2001. Available at http://www.nema.go.kr/nema cms_ilna/shoe_nema/board/boards/list.jsp?tab_no=2&sr_relation=38&check_the_num=142&check_the_code=5&check_up_num=165 [accessed on 4 January 2010].
21. Jung JH, Kim M, Yim UH, Ha SY, An JG, Won JH, Han GM, Kim NS, Addison RE, Shim WJ. Biomarker responses in pelagic and benthic fish over 1 year following the Hebei Spirit oil spill (Taean, Korea). Mar Pollut Bull 2011; 62: 1859-66.
22. Statutes of the republic of Korea. Framework act on the management of disaster and safety. 2004. Available at http://www.korea.kr/kgg/ service/la3/TotalSearch.do [accessed on 11 December 2012].
23. Centers for Disease Control and Prevention. Emergency preparedness and response. Available at http://emergency.cdc.gov/masscasualties/re- search [accessed on 7 November 2011].
24. Rayens MK, Hahn EJ. Building consensus using the policy delphi method. Policy Polit Nurs Pract 2000; 1: 308-15.
25. Seaman J. Disaster epidemiology: or why most international disaster relief is ineffective. Injury 1990; 21: 5-8.
26. Task Force on Quality Control of Disaster Management; World Association for Disaster and Emergency Medicine; Nordic Society for Disaster Medicine. Health disaster management: guidelines for evaluation and research in the Utstein Style: volume I. conceptual framework of disasters. Prehosp Disaster Med 2003; 17: 1-177.
27. Thacker MT, Lee R, Sahogal BJ, Henderson A. Overview of deaths associated with natural events, United States, 1979-2004. Disasters 2008; 32: 303-15.
28. French J, Ing R, Von Allmen S, Wood R. Mortality from flash floods: a review of national weather service reports, 1969-81. Public Health Rep 1983; 98: 584-8.
Appendix 1. Incident report criteria of NEMA* (Article 3 in Fire Basic Act No.11690)

1. Fire which belongs to one of the following criteria
   A. Fire with more than 5 deaths or 10 casualties
   B. Fire with more than 100 people affected
   C. Fire with financial loss of more than 2 billion won (KRW)
   D. Fire at government buildings, schools, rice-polishing mill, cultural assets, subways, or underground tunnel
   E. Fire at tourist hotel, building with more than 11 stories, underground shopping street, market, department store, manufacturer/storage/station of dangerous materials which are more than 3,000 times of standard, accommodations with more than 5 stories or 30 guest rooms, hospital with more than 5 stories or 30 patient rooms, mental institution, oriental-medicine hospital, nursing home, plant with area of more than 15,000 m², and fire in Fire Alert Area according to Article 4-1
   F. Fire at train, ship heavier than 1,000 tons, aircraft, power plant, or power transforming station
   G. Fire by explosion of gas or gunpowder
   H. Fire at publicly used establishments

2. Disaster where incident management is required by controller according to the relevant law
3. Disaster broadcasted by media
4. Disaster which is otherwise selected by administrator of NEMA (Amended on February 1, 2007)

*NEMA, National Emergency Management Agency.

Appendix 2. NEMA* directive for fire investigation and incident report (No.229)

Article 45 (Emergency Incident Report) Fire Chief or Fire Commissioner shall report to the administrator of NEMA for the following incidents during investigation. (Attachment deleted on December 27, 2006)

1. Large-scale fire
   A. Human damage: fire with more than 5 deaths or 10 casualties
   B. Property damage: fire with estimated financial loss more than 5 billion won (KRW) (Revised on July 7, 2009)

2. Major fire
   A. Fire at public buildings and facilities such as government buildings, schools, rice-polishing mill, cultural assets, subways, or underground tunnel
   B. Fire at tourist hotel, high-rise building, underground shopping street, market, department store, manufacturer/storage/station of dangerous materials, fire-vulnerable subjects, and fire in Fire Alert Area
   C. Fire with more than 100 people affected

3. Special fires
   A. Fire at train, ship stationed at seaport, aircraft, power plant, or power transforming station
   B. Special incident, fire with special cause (e.g. arson)
   C. Fire at foreign embassy and residence
   D. Fire at a special location which public attention is expected

*NEMA, National Emergency Management Agency.

Appendix 3. Immediate incident report criteria of some provinces

A. Fire/disaster with fire
   - Deaths of more than 1 person
   - Financial loss of more than 100 million won (KRW)

B. Fire at bazaar market

C. General fire
   - Deaths of more than 3 people
   - Financial loss of more than 500 million won (KRW)

D. Fire at publicly used establishments such as study residence or Karaoke room
   - Deaths of more than 2 people or 3 casualties

E. Emergency incidents such as large-scale collisions and building collapse where rapid rescue & EMS service are required
   - Deaths of more than 3 people or 5 casualties

F. Incident with massive people affected
   - More than 50 people affected

G. Incident with multiple EMS service
   - Casualties more than 10 people

H. Fires and incidents involving other important national establishments or special fire which may draw public attention and broadcasting by media is expected
   - 2 seriously wounded people can be considered as 1 death and used to decide whether to report
### Appendix 4. Incident report criteria of NEMA* dispatch center

A. **Incident report criteria for the administrator of NEMA***

| A. Human damage or damage is expected |
|---------------------------------------|
| - Incident with more than 3 deaths or 10 casualties |
| - Incident with 50 affected people and more # Incident which requires rescue operation/EMS service |

| B. Fires |
|---------------------------------------|
| - Vulnerable subjects: large-scale fire at bazaar market or other places |
| - Publicly used establishments: 2 deaths or more / 3 casualties or more |
| - General fire |
| - 3 deaths or more (2 casualties = 1 death) |
| - Financial loss of more than 200 million won (KRW) / when the second damage is expected |

| C. Security accidental: explosion, collapse, large-scale car crashes |
|---------------------------------------|
| - Damage at major establishments, theater, auditorium |
| - When rapid rescue/EMS are required # 3 deaths or more / 5 casualties or more |

| D. Earthquake (tsunami) |
|---------------------------------------|
| - Over 3.0 (inland)/over 3.5 (coast) |
| - When warning or alert for tsunami is issued |

| E. Mountain fire, others |
|---------------------------------------|
| - In case of mountain fire: when fire spread is expected / When residential or human damage are expected |
| - Opening of water gate at dam near border, mountain fires, etc. |

| F. Fires and incidents involving other important national establishments or special fire which may draw public attention and broadcasting by media is expected |
|---------------------------------------|

* NEMA, National Emergency Management Agency.

B. **Incident report criteria for the minister of MOPAS***

| A. Human damage: 5 deaths or more / major disasters |
|---------------------------------------|
| B. Fires |
| - 5 deaths or more / 20 casualties or more |
| - Major national establishments / underground shopping street and other special fire |
| - Mountain fire more than 30 ha |

| C. Rescue/EMS: 5 deaths or more / 20 casualties or more |
|---------------------------------------|
| D. Others |
| - Massive explosion accidental including gas / collapse / special incident |
| - Any accidental to which public attention is expected |

* MOPAS, Ministry of Public Administration and Security.