A Case Series Analysis of Mass Casualty Incidents

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Abstract

Introduction. Mass casualty incidents (MCIs) are infrequent but potentially overwhelming events that can stress the capabilities of even the most organized emergency medical services (EMS) system. The Maryland EMS system has been identified as a pioneer and leader in the field of prehospital emergency care and, as with many states, Maryland's regional preparation for MCIs has been integrated into its overall EMS systems planning. **Objective.** To determine how successful this integration has been by examining a three-year history of response to MCIs in Maryland. **Methods.** A three-year case series of MCIs in Maryland was obtained from a Nexis national news publications search. These MCIs were cross-referenced with U.S. postal ZIP codes and the U.S. Census Bureau's ZIP code files. They were then mapped and summary statistics were prepared for analysis. Data obtained through the Maryland Health Services Cost Review Commission for all severely injured patients discharged from Maryland hospitals were obtained over the same three-year period for comparison. **Results.** Eight MCIs occurred over a three-year period, resulting in a total of 203 injuries. An average of 25.4 ± 10.7 injuries occurred per MCI. A total of 158 (77.8%) of injuries necessitated ambulance transportation. An average of 3.1 ± 1.1 hospitals were involved per MCI. **Conclusions.** The Maryland EMS system was effective in responding to MCIs ranging in size from 10 to nearly 40 injuries. Analyzing MCIs that reoccur on a year-to-year basis should figure into the planning process for EMS systems. **Key words:** mass casualty; emergency medical services system.

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State emergency medical services (EMS) systems have been primarily established to respond to the day-to-day burden of emergencies. Although many EMS system hospitals participate in some level of disaster planning, it is unclear how the overall EMS system repeatedly responds to times of unusually high demand. A historical evaluation of such times would be of value in planning EMS systems. In the United States, this need is heightened by the perceived threat of mass casualties resulting from terrorist activities.[1–3]

The Maryland EMS system has been called a national pioneer and leader in emergency care.[4] Created in 1973 by executive order of the governor of Maryland, the Maryland EMS system has grown into a coordinated response plan ensuring appropriate access to a system of dedicated and expert personnel at specialized facilities.[5,6] As with many states, Maryland's preparation for mass casualty incidents (MCIs) has been integrated into its overall EMS systems planning.[4]

Mass casualty incidents, when they do occur, can heavily burden a state's EMS system. Severe injuries impose a similarly heavy burden on a state's EMS system. In order to better understand the effect of MCIs on state EMS systems, this paper presents a three-year geographic case series of MCIs in Maryland. By analyzing the locations and intensities of MCIs and the locations of severe injuries, state EMS systems planners can be better supported in planning for the occurrence of MCIs and in projecting the impact of an MCI on the routine operations of their system.

Methods

The following analyses involved the use of administrative and public record data. However, because the nature of some of these data was considered confidential and involved human subjects, appropriate institutional review board approval was obtained prior to this study.

Mass Casualty Incidents

A Nexis search of newspaper and magazine articles was performed for the period May 1993 to May 1996. Nexis provides computer-based bibliographic searches of business, financial, corporate, and related national news publications. For each year of the study that the Nexis search engine was applied, the same text word combinations were used to identify articles using the following Boolean search algorithm: ["mass" AND ("casualty" OR "casualties" OR "injury" OR "injuries")] OR ["multiple" AND ("casualty" OR "casualties" OR "injury" OR "injuries")]. This insured the reliability of the Nexis search among each of the three years of our analysis.

The three-year Nexis search produced a total of 256 articles from local and national news sources. These 256 articles were reviewed by hand for MCIs occurring in Maryland and involving at least ten injuries. The cutoff of ten injuries was selected based on information

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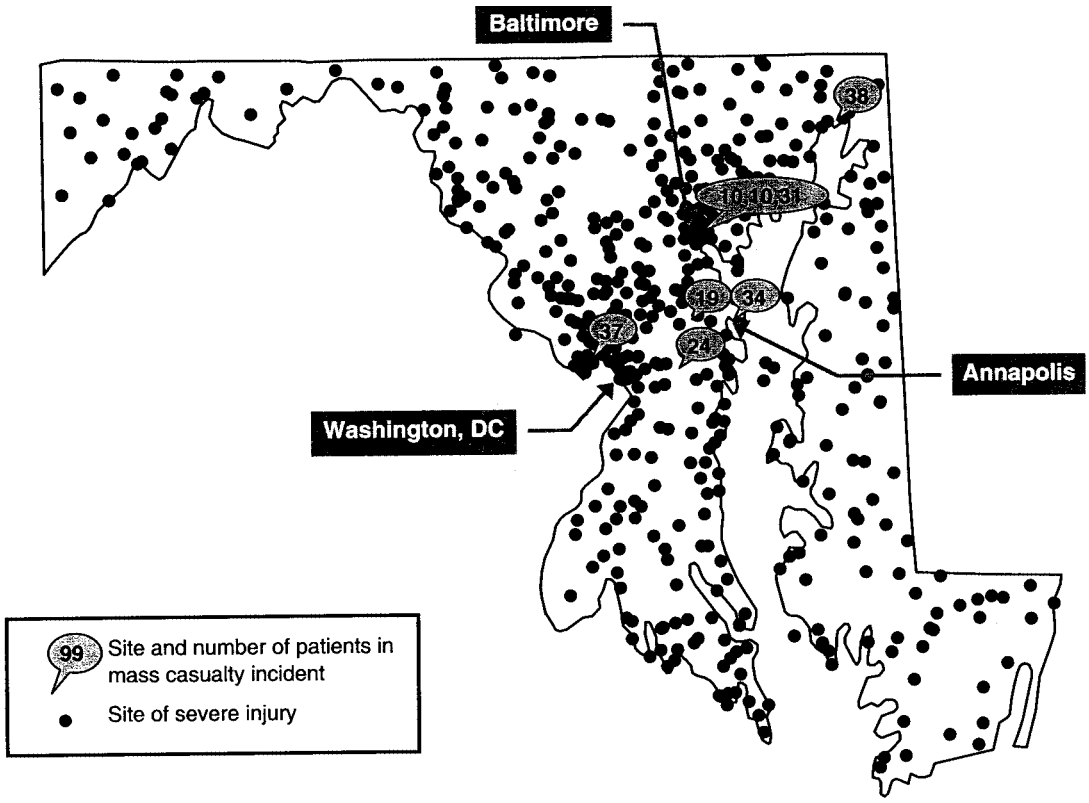

FIGURE 1. Geographic comparison of mass casualty incidents and day-to-day severe injuries in Maryland.

given to out-of-hospital providers for handling field situations where multiple rescue teams and multiple hospitals were potentially warranted.[6] We also selected this cutoff in an attempt to enhance the validity of the MCIs in our study. Smaller multiple-casualty incidents (i.e., those with fewer than ten injuries) were less likely to be reported by national news services and were therefore less likely to appear in a Nexis search.

Following the Nexis identification of MCIs, longitude and latitude coordinates for the centroids of all Maryland ZIP codes were obtained from the U.S. Census Bureau's Tiger Mapping Service Gazetteer website via file transfer protocol (http://ftp.census.gov/geo/www/gazetteer/places.html). These ZIP code files are public record data. Each ZIP code file contained a longitude field (in decimal degrees) and a latitude field (in decimal degrees). Taken together, the longitude–latitude coordinates of each ZIP code represented the point location of its centroid. The centroid is the central location or center of mass within each ZIP code. The centroids that were obtained from the U.S. Census Bureau were weighted as a function of both the planar shape and the population distribution of each ZIP code.

Each MCI identified was assigned a ZIP code of occurrence based on the town named in the Nexis search. Using the longitude and latitude coordinates for the centroids of the Maryland ZIP codes obtained from the U.S. Census Bureau, MCIs were placed on a map of Maryland for comparison with the geographic distribution of severe injuries in Maryland. Case information and summary statistics for the MCIs were then collected for comparison with severe injuries in Maryland.

Severe Injuries

Severe injuries occurring within the State of Maryland were also geographically examined at the ZIP code level. This was first accomplished by obtaining data through the Maryland Health Services Cost Review Commission for all patients discharged from Maryland hospitals with a diagnosis of trauma over the same three-year period, May 1993 through May 1996. Trauma diagnoses were defined as ICD-9-CM diagnosis codes between 800 and 957, excluding those for foreign bodies (930 to 939), traumatic complications (958), and late effects of injuries (905 to 909). Using the ICD-9-CM diagnosis codes, each injured patient was assigned a computer-generated Injury Severity Score.[7] Severely injured patients were identified by an Injury Severity Score higher than eight and were queried for analysis because they were most likely to impact the general operations of the Maryland EMS system. A map of the ZIP code centroids of these severe injuries was then created for Maryland. On this map were superimposed the locations of MCIs for comparison (Fig. 1).

RESULTS

The analysis of general injuries over the three-year period in Maryland produced an average of 12,478 severe injuries per year beginning in May 1993. This translated into an average annual incidence of 2.61 severe injuries per 1,000 Maryland residents. Considering each of the three year periods in succession, the prevalence rates were: 2.57, 2.71, and 2.55 severe injuries per 1,000 Maryland residents within each year.

Over the three-year study period, Maryland also experienced eight incidents that involved ten or more simultaneous injuries. These MCIs are detailed as follows:

- *Case 1:* On May 22, 1993, a canister of tear gas unintentionally discharged inside a school bus, poisoning 19 children between the ages of 6 and 11 years in Odenton, Maryland. All 19 children suffered serious breathing problems and were transported by ambulance to three Maryland hospitals.
- *Case 2:* On August 21, 1993, 24 people were injured when an automobile crashed into a restaurant in Millersville, Maryland. All 24 injuries were transported to four Maryland hospitals, 13 by ambulance and 11 by nonmedical means. Four of these injured people were hospitalized with serious injuries.
- *Case 3:* On July 18, 1995, a train carrying more than 100 passengers derailed due to hot weather in Baltimore. A total of 31 passengers were moderately injured. All were transported by nonmedical means to a single Maryland hospital for evaluation and treatment.
- *Case 4:* On August 8, 1995, ten people, five of whom were less than 16 years of age, sustained gunshot wounds in Baltimore. Penetrating injuries ranged from critical thoracic wounds to minor lower extremity graze wounds. All ten people were transported to four Maryland hospitals for treatment, eight by ambulance and two by nonmedical means.
- *Case 5:* On November 25, 1995, an interstate highway bus crash injured 38 people near Elkton, Maryland. No deaths were immediately reported, although eight people sustained injuries serious enough to warrant hospitalization. Thirty-seven of the 38 injured people were medically transported to three Maryland hospitals. One injured individual was medically transported to a nearby hospital in Delaware.
- *Case 6:* On January 30, 1996, ten people were injured in a Baltimore rowhouse fire. Five of these injured people were children. All ten injured people were medically transported to two Maryland hospitals, where they were subsequently admitted. Six of the injuries were severe or life-threatening.
- *Case 7:* On February 16, 1996, the collision of two commuter trains in Silver Spring injured a total of 37 people. Twelve of these people died either within 24 hours or on scene. All 37 people, including those who had died, required ambulance transport to three Maryland hospitals and a temporary morgue site. Two nonfatally injured individuals were taken to a fourth hospital in Washington, DC.
- *Case 8:* On April 2, 1996, a 44-year-old man was killed when his car crashed head-on into a school bus carrying 33 children. The crash occurred in Annapolis and resulted in a total of 34 injured patients transported by ambulance to three Maryland hospitals.

These eight MCIs resulted in a total of 203 injuries over the three-year study period, for an average of 67.67 injuries per year. This translated into an average annual incidence rate of 0.014 injuries per 1,000 Maryland residents and a three-year incidence rate of 0.042 injuries per 1,000 residents. The mean number of injuries was 25.38 ± 10.70. A typical MCI over the three-year study period produced 27.5 injuries, the median number of injuries.

All eight MCIs were located at or near major population centers or major highways. Six of the eight MCIs involved transportation mishaps and only case 3 could be attributed indirectly to weather. Seven of the eight MCIs were geographically clustered within the Baltimore–Annapolis–Washington triangle. The spatial clustering of these seven MCIs, within the triangle, is similar to that of the severe injuries. The one MCI outside of the triangle coincidentally had the highest number of injuries (Fig. 1).

While one MCI did not necessitate medical transport services, all eight MCIs necessitated an on-scene medical response. All 203 injured patients were taken to area hospitals, 158 (77.8%) of these by medical transport. Only three (1.5%) of the 203 injured patients were taken to hospitals outside of Maryland. The number of hospitals involved ranged from one to four, with a mean of 3.13 ± 1.05. A typical MCI over the three-year study period involved 3.5 hospitals, the median number of hospitals reported (Table 1).

DISCUSSION

Definition of Key Terms

The emergency medical response required for MCIs can be classified into three "levels of intensity." These categories dictate the personnel and resources required to properly address the number, severity, and spatial distribution of injuries in an MCI[8]:

TABLE 1. Summary Patient and Resource Statistics Collected for Mass Casualty Incidents Occurring from May 1993 to May 1996

	Number of Injuries	Number of Ambulance Transports	Number of Hospitals Involved
Case 1	19	19	3
Case 2	24	13	4
Case 3	31	0	1
Case 4	10	7	4
Case 5	38	38	4
Case 6	10	10	2
Case 7	37	37	4
Case 8	34	34	3
TOTAL	203	158	25*
MEAN ± SD	25.38 ± 10.70	19.75 ± 13.82	3.13 ± 1.05
MEDIAN	27.50	16.00	3.50

* Note that two hospitals in this total were out of Maryland.

- *Level I Response:* A localized MCI that can be handled by local EMS and rescue resources without mutual aid from outside organizations. This typically translates into only one jurisdictional authority and follows the normal agency chain of command.
- *Level II Response:* An MCI that overwhelms or severely taxes local EMS and rescue resources. Typically, a large number of casualties occur at more than one incident site, overlapping jurisdictional boundaries and thereby necessitating some interagency coordination.
- *Level III Response:* An MCI that overwhelms both local and regional EMS and rescue resources. Multiple casualties are widespread over many incident sites. Typically, there is overlapping of jurisdictional boundaries, necessitating substantial interagency coordination, the establishment of a formal emergency operations center, and the implementation of secondary levels of management.

Disaster Planning within EMS Systems

Unproductive and misdirected approaches to preventing injury mortality are reflected in increases to death and disability.[9] Several studies have shown that the formal coordination of emergency care systems is an effective response to injury.[10–18] Furthermore, it has been estimated that 25,000 of the 150,000 trauma deaths each year are preventable and that trauma systems are effective in reducing preventable deaths by as much as 80%.[19]

The day-to-day operations of an EMS system are, nonetheless, not sufficient during a disaster because everyday management is not oriented to widespread crisis.[20] Emergency medical services system protocols must account not only for routine daily emergencies, but also for situations that place unexpected demands on the system. Although such events occur sporadically, a lack of planning may result in excess preventable deaths due to an unexpectedly large influx of patients in a short period of time.[21]

To satisfy their need for disaster planning, many civilian EMS systems simply designate a single hospital as the control center and receiving point at the time an MCI occurs. This command hospital is linked through appropriate communications to other hospitals in the system that are then activated based on the number and severity of casualties in the field. Satellite hospitals must continually inform the command hospital of their capacity to handle patients. This system can be quickly expanded without having to rely on new or different levels of command or operating procedures.[21]

A more proactive approach to disaster planning within EMS systems is the hospital emergency incident command system, a complete, ready-to-go disaster plan.[20] The incident command system was initially designed to manage the huge number of firefighters who were combating California's major brush fires. Over the past two decades, adaptations of the incident command system have been developed to assist hospital and out-of-hospital services in managing MCIs of all intensity levels. Most jurisdictions modify the basic incident command system structure to fit their own local circumstances.[8]

Recommendations for Future Preparedness

Planning for MCIs requires a straightforward yet well-tested strategy based on the routine operation of the existing EMS system. The first step in establishing this is to design an adequately functioning EMS system at the state level.[21] Although Maryland has a more than adequately functioning EMS system, the level of intensity for all MCIs in Maryland over the study period required no more than a level I response. The volume and severity of patients in each MCI were within the capabilities of the state EMS system: only 1.5% of those injured in Maryland MCIs were taken to out-of-Maryland hospitals over the three-year study period.

The Maryland EMS system is thus capable of contending with MCIs ranging in size from ten to almost 40 injuries. The median demand imposed by 28 simultaneous patients was not shown to disable the Maryland EMS system, which was correspondingly able to activate up to four hospitals to handle the increased volume. Although most MCIs occurred within a triangular area of the state where the EMS system was most intensified in terms of hospital and ambulance resources, the one that fell outside of this area produced the highest number of casualties who were handled almost exclusively by Maryland res-

cuers and hospitals. In the event that a level II or higher response is required outside of the Baltimore–-Annapolis–Washington triangle, mutual aid plans that involve hospitals and ambulances normally external to the state EMS system can be executed to cover the extraordinary demand of casualties.[6,20]

Nevertheless, the high resource costs and low reimbursement levels of emergency care continue to threaten the financial stability of many hospitals and rescue services. Emergency medical services systems must be balanced by resource investments that protect the health of the community in a politically admissible yet cost-efficient manner. This means that systems administrators may be able to plan for only a limited volume of casualties created by a single incident or disaster. Extremely high-casualty disasters or multiple simultaneous MCIs occur so rarely that they could hold a state EMS system "financially hostage" in attempting to fully plan for them. Excessive resource investments for the major catastrophe that is known to occur relatively infrequently (e.g., the "hundred-year flood") should be reconsidered in light of the high costs and the sacrifice in day-to-day emergency care resources that might inadvertently result.

An annual record of smaller MCIs that have a high probability of reoccurrence can provide a more realistic basis of planning for EMS systems. From here, more precise definitions of the response "levels of intensity" can be tailored to a state's specific historical needs. It should be noted, however, that the civilian threat of chemical or biological weapons deserves special recognition in the EMS planning process, not necessarily due to its probability of occurrence (which is relatively small compared with that of the typical MCI), but because of the extraordinarily high numbers of patients who would ultimately present to health care facilities without the benefit of early warning and rapid EMS system response.[1,22]

LIMITATIONS

One major limitation of our analysis is the poor generalizability inherent to any case series study. This limitation is particularly heightened when considering MCIs in a single state because the occurrence of MCIs is infrequent enough to prevent conclusive statistical analyses. Furthermore, the fact that none of our cases required more than a level I response points to an obvious underrepresentation of more serious MCIs. This may be an issue of sample period: more serious MCIs occur with considerably less frequency, and a longer period of study will be required to fully understand their impact on a state's EMS system.

However, the Nexis national news publications search is a reasonably reliable method to identify and study MCIs. As the Nexis database accumulates in size, decades-long, statistically robust studies of MCIs will be possible. Such studies will provide EMS systems planners with valuable guidance in engineering their systems to be more efficient and reduce potentially preventable deaths that occur during MCIs.

CONCLUSION

Mass casualty incidents are infrequent but potentially overwhelming events that can stress the capabilities of even the most organized EMS system. The eight MCIs that occurred over the three-year study period were adequately absorbed into the routine operations of the Maryland EMS system. These MCIs ranging in size from ten to nearly 40 injuries. Seven of these MCIs occurred within an area of the state where the number of day-to-day severe injuries was most concentrated and where the EMS system was most intensified in terms of hospital and ambulance resources. Regular analyses of MCIs that reoccur on a yearly basis should be a routine component of the EMS systems planning process.

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SIRENS

Aphasic

Stroke: Lights out, words out. Right side out.
"How are you today?" I think I hear you.
Fierce lightening, Cataclysmic wind sweeping my brain.

Gone. Words, flowers as full of color as my Dutch…my Dutch…Is it Tulips? It's something.

"How are you today?" do you again say?
How do I answer without, Tulips…words, something?
Even though you are asking, I can't tell you who you are…doctor, therapy, something…somebody.

But stay. Hold my hand that's sensate.
Read my eyes.
Give me "yes." Give me "no."
Give me something for which I have no name.

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