REVIEW

Human Stampedes: A Systematic Review of Historical and Peer-Reviewed Sources

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Human stampedes, which occur around the world, are an important and unique yet incompletely understood type of disaster resulting from complex and often lethal dynamics that occur at large crowd gatherings. Given that human stampedes are a recurring phenomenon that can trigger mass casualties ranging into the thousands, they must be considered alongside other significant causes of disaster events. By definition, a stampede may be characterized as an impulsive mass movement of a crowd that often results in injuries and deaths. Another commonly associated term is trampling that leads to infliction of crushing casualties. Although human stampedes have widely been reported in the media, they have attracted scant scientific attention or investigation, limiting basic understanding of the pathophysiology and behavioral aspects of these events. This article is a review of elements within the context of historically significant human stampedes and specific events described in the literature. Strategies for preincident preparedness informed by improved systematic categorization and identification of human stampede determinants including pathophysiology, mechanisms, settings, and triggers are explored.

HUMAN PATHOPHYSIOLOGY OF STAMPEDES

The vast majority of human stampede casualties result from traumatic asphyxia caused by external compression of the thorax and/or upper abdomen, resulting in complete or partial cessation of respiration.[1–8] Significant compression forces can be present with even moderate crowds; forces of up to 4500 N (1000 lb) can be generated by just 6 to 7 people pushing in a single direction with forces large enough to bend steel railings.[9,10]

The earliest stampede victims with facial petechiae were characterized as "masque ecchymotique."[5–8] Subpleural petechiae termed "Tardieu spots" and Perthes's clinical description formed the original definition of traumatic asphyxia or crush asphyxia.[5,6,8,11,12]

Clinical signs include conjunctival petechiae, facial petechiae, cutaneous blue–purple discoloration and congestion of the face and neck, and seizures, confusion, and unconsciousness.[5–8] In forensic studies, up to 95% of cases presented with at least 1 of the 3 classical signs—conjunctival petechiae, facial petechiae, and congestion of the face and neck attributed to venous congestion from external pressure hindering venous flow.[7,8] Neurological findings, such as loss of consciousness and confusion due to cerebral anoxia, were believed to be transient and no specific pathological brain tissue findings were reported.[7,13,14]

Although survivors of human stampedes and autopsy reports suggest traumatic asphyxia as the primary cause of death, other mechanisms have been considered, including myocardial infarction, direct crushing injury to intrathoracic or intraabdominal organs, head injury, and neck compression.[15] All of these mechanisms are possible; however, little actual supportive evidence exists.

Gill and Landi[1] concluded from autopsy findings that "people who succumb in these scenarios typically die (standing up) in a vertical position" due to compression force and "do not collapse to the floor until after the crowd density and pressure have been relieved." Compressive forces applied front to back or vice versa resulted in ventilatory failure, whereas those experiencing compressive forces from side to side were spared, presumably because chest expansion was not compromised to the same extent.

The full spectrum of injuries—including fractures, dislocations, and other mechanical injuries—may be expected. Among survivors, many may suffer from posttraumatic stress, grief, or survivor guilt and require psychological counseling or intervention.[16]

STAMPEDE MECHANISMS

Models have been developed to depict behavior with pedestrian flow.[17] To date, only a few studies take into account the social–psychological behavior of escape panic[18,19] (Table 1). In situations leading to stampedes, crowds do not stop accumulating even with local densities up to 10 people per square meter. Quantitative measurement taking into account crowd density and speed of movement have been suggested as predictive warning signs of a stampede.[18,19] Classic escape panic is described by a "headlong rush away from something" while a craze is "a rush toward something believed to be gratifying."[20,21] In either situation, psychological elements play a central role in stampede events, which effectively always involve mass behavior.

https://doi.org/10.1097/DMP.0b013e3181f5b942 Published online by Cambridge University Press

TABLE 1

Features of Escape Panic

People move or try to move considerably faster than normal.
Individuals start pushing, and interactions among people become physical in nature.
Moving, and in particular, passing of a bottleneck becomes uncoordinated.[22]
At exits, arching and clogging are observed.
Jams build up.[23]
The physical interactions in the jammed crowd add up and cause dangerous pressures up to 4450 N/m^2, which can bend steel barriers or push down brick walls.[9,10]
Escape is slowed further by fallen or injured people acting as obstacles.
People show tendency toward mass behavior, mimicking what other people do.[24,25]
Alternative exits are often overlooked or not efficiently used in escape situations.[9,25]

Human stampedes may be characterized as unidirectional or turbulent. Unidirectional stampede events may occur when a crowd moving in the same direction encounters a sudden positive or negative change in force, thus altering the movement of the crowd. Examples of positive forces include a "sudden stop" situation, such as the closing of a door or gate or a fallen bystander.[3,20,26] Positive force can also result from narrow passages or a bottleneck phenomenon.[26] A sudden decrease in force, such as in the case of a barrier collapse or gate opening, may also trigger a unidirectional stampede event.[1,2] In contrast, turbulent stampede events can occur in situations with uncontrolled crowds, induced panic, or crowds merging from numerous directions.[19,27]

NOTABLE STAMPEDE EVENTS

Much of what is known about human stampedes is derived from anecdotal news reports and observations.[28–34] In recent decades, the toll from human stampedes has been increasingly well documented. Although there appears to be an uptick in the occurrence of deadly stampedes mirroring risks of increasing overall population densities, especially in the developing world, the number of reports may in reality simply reflect greater sharing of information via mass media. Numerous other events before the 1990s, particularly in less-developed countries, may have resulted in sizeable stampedes that were unreported. In general, injuries are estimated or are not recorded, whereas direct deaths (not including deaths following injuries) are more precisely reported and readily obtained. Although we recognize the subjective nature of categorizing severity based upon resultant mortality, we propose the following logarithmic stampede scale to encompass the entire observed casualty range: class I (mild): injuries, 0 deaths; class II (moderate): 1 to 10 deaths; class III (severe): 11 to 100 deaths; class IV (devastating): 101 to 1000 deaths; class V (catastrophic): >1000 deaths. This scale could be used during operational response to readily convey the estimated magnitude of an event and mobilize necessary resources. Classification according to this scale may also offer a unified nomenclature to facilitate research in identifying characteristics associated with different reported stampede events. Further study is necessary to determine how injuries alone affect the scale of an event and whether any relation exists between injuries and deaths during human stampedes. Table 2 lists the deadliest documented human stampede events.

Mass gatherings during political, sporting, and religious events historically have been important backdrops against which human stampedes occur. Typically, human stampedes are then triggered by a real or perceived inciting event. One of the first documented human crowd disasters occurred on the eve of Russian Tsar Nicholas II's coronation ceremony in 1896 at Khodynka Field near Moscow.[35] Greater than 1000 people were crushed or trampled to death when the crowd surged based on rumors that souvenirs were in short supply. Fearing cancellation of the ceremony would result in further civil unrest, the strewn corpses were quickly removed during the night and the event proceeded as scheduled the following day.

Another infamous incident occurred in 1913 during the Italian Hall disaster in Calumet, Michigan, when the false warning of "Fire!" was shouted during a holiday gathering of about 700 striking copper mine workers and their families.[36] During the ensuing panic, people stumbled and fell on the stairs, leading to a pileup of bodies and 73 deaths, including

TABLE 2

Deadliest Documented Human Stampede Events

Year	Location	Event	Setting	Deaths	Class
1896	Khodynka, Russia	Nicholas II coronation[35]	Political	1389	V
1964	Lima, Peru	Olympic soccer qualifier[29]	Sports	318	IV
1982	Moscow, Russia	UEFA cup at Luzhniki Stadium[30]	Sports	340	IV
1987	Mina Valley, Saudi Arabia	Anti-US rally during Hajj[31]	Religious	402	IV
1990	Mina Valley, Saudi Arabia	Hajj[31]	Religious	1426	V
1994	Mina Valley, Saudi Arabia	Hajj[31]	Religious	270	IV
2004	Mina Valley, Saudi Arabia	Hajj[32]	Religious	251	IV
2005	Baghdad, Iraq	Religious festival[28]	Religious	965	IV
2005	Wai, India	Religious festival[33]	Religious	267	IV
2006	Mina Valley, Saudi Arabia	Hajj[34,47]	Religious	380	IV

women and children. This incident along with other smaller-scale events served as the impetus for the US Supreme Court in 1919 to place certain limitations on the right to free speech, prohibiting acts such as "falsely shouting fire in a theatre and causing a panic."[37]

Sporting events, particularly international soccer matches, have been marred by numerous deadly human stampedes. Two of history's deadliest stampedes occurred in the context of soccer matches. In 1964, a Peruvian stampede leading to 318 deaths was touched off by a controversial referee call during the final minutes of the game.[29] Following another highly contested match in Russia in 1982, 340 fans were killed when some were pushed down a narrow, icy staircase.[30]

Most notably, many of the deadliest stampedes have occurred during various religious events. As the largest annual pilgrimage in the world, the Hajj requires the participation of all Muslims in good health at least once during their lifetime. With availability of modern transportation, more pilgrims are taking advantage of this opportunity from far-off regions of the world. Among the religious rituals, pilgrims circle counter-clockwise 7 times around a building called the *Kaaba* and during another ritual, known as the stoning of the devil, pilgrims throw a series of pebbles at 3 long walls along a path. Once at their destination, the crowds that converge during these rituals can number more than 2 million, raising major safety concerns. Despite increasing Hajj safety regulations, these events have led to tragic major human stampedes in 1987, 1990, 1994, 2004, and 2006, which account for half of the 10 deadliest recorded human stampedes.[31,32,34] In a separate religious festival in 2005, 965 Shia pilgrims perished in a stampede over a river bridge in northern Baghdad, Iraq, when rumors of a bombing spread.[28]

REVIEW OF EVIDENCE-BASED PUBLISHED STUDIES

Methodology

Articles published through September 2008 were identified using 3 electronic databases, including PubMed, the Exerpta Medica database (EMBASE), and the Educational Research Information Clearinghouse (ERIC). Search terms included "stampede," "trampling," and "crowd disaster." All of the abstracts identified through the search were screened for inclusion criteria: English language and pertaining to a human stampede event or crowd dynamics. Citations were excluded if they were non-English language; not related to a stampede event or crowd dynamics; or a description of non-human events. For those that met the criteria, the full article was obtained and hand searches of included references were conducted. Any information regarding location, setting, inciting events, injuries, and deaths was noted using a data collection form.

RESULTS

The literature review identified relatively few published articles pertaining to human stampedes. The PubMed search identified only 8 articles in English of relevance among 137 citations.[2,3,18,19,27,38–40] Hand searches of published references identified an additional 12 relevant articles.[1,4,9,20,26,41–47] Sixteen citations were returned from ERIC, none of which met inclusion criteria. No citations that met inclusion criteria were returned from the search of EMBASE.

Since 1970, only 8 human stampedes have been described in detail in the peer-reviewed literature (Table 3), the majority of which took place in the United Kingdom or the United States (5 of 8).[2–4,9,20,26,27,38,41–47] More than half of the stampedes reported (5 of 8) were in the setting of sporting events, notably soccer games. Other mass gatherings such as concerts and religious occasions were associated with the other stampedes (3 of 7). Three events were triggered by falls, 2 events were triggered by locked doors or fixed barricades, and another 2 events resulted from sudden gate opening or barrier collapse. Events ranged from those with no fatalities to 380 dead. In general, the events described were smaller in scale with references to 1 class I event, 1 class II event, and 5 class III events. There was a single class IV event and no mention of class V events, the deadliest of recorded human stampedes. Although we sought to identify patterns, the sparseness of published literature on the topic of human stampedes combined with a complete absence of reports on greatest impact events significantly limits the conclusions that can be drawn.

RECOMMENDATIONS

Despite the limited evidence regarding human stampedes, a number of general recommendations can be made. Although

TABLE 3

Human Stampedes Referenced in the Published Literature

Date	Location	Event	Setting	Inciting Event	Injuries	Deaths	Class
January 2, 1971	Glasgow, UK	Ibrox Stadium	Sports	Fall	?	66	III
December 3, 1979	Cincinnati, OH	Who concert	Music	Gate open	?	11	III
April 15, 1989	Sheffield, UK	Hillsborough Tragedy	Sports	Barrier collapse	400	95	III
April 26, 1991	Chittagong, Bangladesh	Zakat distribution	Religious	Fall	100	32	III
December 28, 1991	City College of New York	Basketball game	Sports	Locked door	0	9	II
October 30, 1993	Madison, WI	Camp Randall Stadium	Sports	Fixed barricade	86	0	I
July 09, 2000	Harare, Zimbabwe	National Sports Stadium	Sports	Tear gas	35	13	III
January 12, 2006	Mina, Saudi Arabia	Hajj	Religious	Fall	289	380	IV

https://doi.org/10.1097/DMP.0b013e3181fdb4a4 Published online by Cambridge University Press

mass gathering medicine has focused on events that have more than 1000 people in attendance, fatal stampedes have occurred with less than half that number. The combination of high crowd density and difficult access points can set the stage for catastrophic human stampedes, particularly when the element of fear is introduced. Focused crowd control methods must be practiced even when there is moderate crowd density and a sufficient number of exits. Particular attention should be paid to clearly marking pressure points—such as entry points, exits, and stairwells—balancing crowd dispersion while offering reliable ingress routes to rescue personnel in the event of an emergency.

Current crowd control policies are based largely on experiences from past disasters. For example, basic changes such as controlling admission to events, increasing the number of paramedic teams present, and selecting an independent radio frequency or improved communication systems have been proposed.[1,2,4,38] To reduce risks of communications failure, cell phone override codes, dedicated land lines, and prearranged radio frequencies may be considered as possible strategies.

Finally, several events have led to changes in long-established customs or systems. In the Zimbabwe soccer stadium disaster, a nationwide campaign in disaster preparedness and management followed as well as a systematic change in prehospital emergency medical services.[38] In many developing countries, medical preparations at mass gatherings are typically nonexistent or provide only first aid at best. In Saudi Arabia, changes after the 2006 Hajj disaster included expansion of the Jamarat Bridge, establishing single-direction traffic, automating visitor counts, and systematic scheduling and routing programs.[19,47]

Preplanning must include the possibility of a large-scale disaster that quickly overwhelms the local resources. The Hajj is a relatively unique scenario that entails high risk; temporary medical tents or seasonally used hospitals may be opened and closed depending on the required surge capacity. Immediate field-to-hospital notification and access to a system of nearby triage stations and hospitals enhance the capability to respond to the occurrence of a human stampede. This systems-based approach works most efficiently when the triage stations and hospitals have established appropriate staffing and preexisting incident command structure for multiple casualties covering the times of peak danger.

Systematic information, surveillance, data gathering, and analysis regarding human stampedes are needed. Development of a comprehensive events database for human stampedes is a first step toward improved understanding of this phenomenon. In lieu of scientific reports, nontraditional information sources, such as media reports, may represent a starting point from which detailed information can be garnered, although the accuracy of such information must be carefully verified. We suggest formal reporting with standard parameters for inclusion in existing international disaster databases.[48] With increasing attendance at mass gathering events, the lessons learned from human stampedes must be taken into careful consideration. As with other types of disasters, comprehensive examination of past human stampedes may guide detailed and thoughtful planning to mitigate attendant future risks.

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Received for publication June 12, 2008; accepted December 30, 2008.

Authors' Disclosures

The authors report no conflicts of interest.

ISSN: 1935-7893

DOI: 10.1097/DMP.0b013e3181c5b494

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