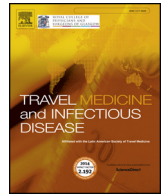




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From the “Madding Crowd” to mass gatherings-religion, sport, culture and public health

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ABSTRACT

Human behavior has long engaged in collective behavior assembling in crowds. The Christian pilgrimage to the Holy Land has been recorded since the 4th century, while the Hajj, Islam's great pilgrimage, has existed for fourteen centuries, of which a body of literature devoted to the travelogues of the Hajj has been recorded for over ten centuries. Football is a sport played worldwide by more than 1.5 million teams and in 300,000 clubs. Most however play outside of the officially organized sphere: more than 4 percent of the global population plays football, including 270 million amateur players.

Assembling for specific events is a uniquely human behavior, though the formal study of crowds did not begin until the mid-Twentieth Century. Today Mass Gathering Medicine focuses on the public health challenges to hosting events attended by a large enough number of people, at a specific site, for a defined period of time, likely to strain both the planning and response to the mass gathering of a community, state, or nation. All of us can recall attending a mass gathering, whether it be watching one's favorite rock group in performance or assembling for religious pilgrimage. Certainly, the event itself is transporting and transforming and the unison of behaviors and activities can be enormously enriching, uplifting and overwhelming, just as much as they may be at times dangerous and high risk. This review seeks to draw contrasts and comparisons between sporting gatherings and religious gatherings with a chief focus on Hajj, among the largest of all mass gatherings today. We will find there are some powerful similarities as well as stark differences. Each bequeaths a legacy which can inform the other and, as we make our observations, we join with you and the legions of other investigators who continue to remain fascinated and enthralled by mass gatherings which are among the most beloved and beholden events of modern humanity.

1. Mass gatherings as collective behavior: a modern history

Human behavior has long engaged in collective behavior assembling in crowds. Built 2500 years BCE, Stonehenge in the British Isles is thought to be the first monument and evidence of mass gatherings in the Pre-Historic era [1]. Numerous burial sites have been found at the now designated UNESCO World Heritage Site adding to the belief that it was a focus of spiritual energy and ritual. Christian pilgrimage to the Holy Land has been recorded since the 4th century. The Hajj, Islam's great pilgrimage, has existed for fourteen centuries of which a body of literature devoted to the travelogues of the Hajj has existed for over ten centuries [2]. In 1750, Thomas Gray's 'Elegy Written in a Country Churchyard' referred to the 'Madding Crowd's ignoble strife' at once

holding forth the sobriety on common ordinary country folk in contrast to the madding crowd which drove men to disgraceful uncontrolled and even violent behavior captured in the timeless phrase [3]. In 1852 Charles McKay published his treatise on “Extraordinary Popular Delusions and the Madness of Crowds” writing that ‘Men, it has well been said, think in herds; it will be seen that they go mad in herds, while they only recover their senses slowly, and one by one.’. In 1874, the great writer Thomas Hardy wrote a novel which still remains recognized as a masterpiece of English literature, “Far from the Madding Crowd,” focusing on the lives of rural dwellers who were left behind by the madding crowd of industrialization. Even today the ‘madness of crowds’ continues to fascinate and enthrall.

Assembling for specific events is a uniquely human behavior,

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though the formal study of crowds would not begin until the mid-Twentieth Century. The civil rights movements sweeping across the United States in the 1960s and the crowds that cycles of violent lynchings had drawn prior, first captured the attention of Behavioral Scientists interested in public gatherings. Psychologists referred to the ‘collective mind’ (first observed by 1895 thinker Gustav Le Bon) that developed when large numbers of people gathered to be together, and the ‘de-individuation’ that followed as a result whereby not individuals, but the larger group determines actions accounting for violence destruction and even murder that could result [4]. Two schools of investigation developed, those focusing on disaster relief – the public health needs of large number of people escaping or evacuating from a threat- and those who studied protest events.

While many theories of behavior were proposed, researches remained mostly removed from the gatherings themselves and very little research was performed by direct observation of public gatherings themselves. At the time, modern travel had not yet permitted some of the massive scale of gatherings which have become commonplace since the late twentieth century.

Today mass gathering medicine focuses on the public health challenges to hosting events attended by a large enough number of people at a specific site for a defined period of time to strain the planning and response of a community, state, or nation. The definition is purposefully not linked to the size of the gathering or the number of people because each community has a varying capacity to manage crowds of people. All of us can recall attending a mass gathering, whether it be watching one's favorite rock group in performance or assembling for religious pilgrimage. Certainly, the event itself is transporting and transforming and the unison of behaviors and activities can be enormously enriching uplifting and overwhelming, just as they may be at times dangerous and high risk.

This review seeks to draw contrasts and comparisons between sporting gatherings and religious gatherings with a chief focus on Hajj, among the largest of all mass gatherings today. We will find there are some powerful similarities as there as stark differences. Each bequeaths a legacy which can inform the other and as we make our observations we join with you and the legions of other investigators who continue to remain fascinated and enthralled by the mass gatherings which are among the most beloved and beholden events of modern humanity [5].

2. Perspectives on the threshold of the upcoming FIFA world cup

As this article goes to press, one of the most awaited mass gatherings in modern history – the FIFA World Cup 2018 is underway [6]. The size of football is difficult to comprehend, nothing else compares in scale: football dwarfs the United Nations, and even Coca-Cola, in international reach. Across the globe, almost most five million referees, assistant referees and officials are directly involved in football, a sport played worldwide by more than 1.5 million teams and in 300,000 clubs. Most people however play outside of the officially organized sphere. More than 4 percent of the global population plays football, including 270 million amateur players.

3. Monotheisms, long congregating in mass gatherings, are on the rise

Most people are religiously affiliated. According to the Pew Research Center report examining the Global Religious Landscape published in December 2012, over 5.8 billion people-adults and children-are religiously affiliated [7]. At the time of this survey conducted examining more than 230 sovereign nations and territories, this amounted to 84% of the world population.

While religions diversity is panoramic, three theisms predominate: Christianity, Islam and Hinduism. The Pew study examined 2500 censuses surveys and other registers of population finding 2.2 billion Christians (32% of the world's population), 1.6 billion Muslims (23% of

global population) and 1.0 billion Hindus (15% of global population). A half billion identify as Buddhist and 14 million as Jews-followers of Judaism [7]. Some 400 billion follow folk or traditional religions (including African traditional religions or Chinese folk religions or Native American religions). And, while well known, a tiny proportion-less than 1% of the earth's population-follow other religions including the Yazidism, the Bahai faith, Sikhism, Zoroastrianism and others.

Worth noting is that the religiously unaffiliated are themselves a group of over 1 billion- 16% of the global population as populous as some leading theisms. The unaffiliated include atheists, agnostics and those declining to identify with any religion on surveys [7].

Yet the fastest growing population in the world is the Muslim population-it is expected to increase by 35% in the next twenty years [7]. By 2030 the global Muslim population is expected to reach 2.2 billion-rising more than twice the rate of the non-Muslim population at a 1.5% growth rate compared to 0.7% annual growth rate for non-Muslim populations. While slower than the 2.2% annual growth rate of Muslims in the past thirty years, by these calculations, Muslims will account for 26.4% of the 8.3 billion global population estimated by 2030.

4. Mass gatherings- religious and sporting events

While the Muslim world is long familiar with hosting one of the world's largest mass gatherings-the Hajj, Islam's pinnacle of worship which centers on Mecca in Saudi Arabia, and to where millions of Muslims travel from within the Muslim world to the Saudi Kingdom -a sporting event of the scale of the World Cup, itself one of the world's larger mass gatherings is an unprecedented mass gathering event. Among religious gatherings, it is also the best studied informing the public health risks of mass gatherings across the world.

In some ways football, the Beautiful Game reaches the dimensions of a religion given its vast appeal and global reach and devoted followers. But it is useful to consider the World Cup as a sporting event on a par with the Summer Olympics and the more recently developed Paralympics while the Hajj as a mass gathering centering on Islamic belief is better understood within the context of other mass gatherings centered on other theist belief systems including the Hindu Kumbh Mela, World Youth Day and other pilgrimages [8–10].

5. Theist religious events involving mass gatherings

Christian Mass Gatherings include the World Youth Day, held every two or three years by the Catholic Church when almost a quarter of a million young Catholics attend a mass gathering centered in varying cities for a live event anchored by the Pope, first initiated by the late Pope John Paul II in 1985 [10]. World Youth Day will be next held in Panama in 2019. The events are massive. The closing mass of the 1995 World Youth Day in the Philippines drew 5 million attendees, one of the world's largest mass gatherings at the time only to be surpassed in 2015 when 6 million gathered to World Youth Day led by Pope Francis in The Philippines [11].

More well-known and rooted in centuries of observance may be the Christian pilgrimage to Lourdes in France, a year-round event drawing more than 5 million in worship. Lourdes, a small town in the Southern Pyrenees, itself has a population only of 15,000 yet because of the pilgrimage which has existed since 1858, it is now the second most visited city in France, second only to Paris. In the Catholic world, it is the third most important site of pilgrimage after the Holy Land and Rome [12].

In Asia, on one day, almost 8 million Catholics gather in Christian Procession for the Feast of the Black Nazarene. The Black Nazarene is life-sized wooden statue of Jesus Christ crowned with thorns believed to have been brought from Mexico to Manila on a galleon in 1606 by Spanish missionaries. The galleon that carried it to the Philippines caught fire, but the charred statue survived and was named the Black Nazarene. Devotees gather for the 20-h procession around the holy icon

which followers believe delivers miracles.

The world's largest mass gathering however occurs in India. The Kumbh Mela is held periodically over twelve-year cycles, rotating in four different Indian cities-Allahabad, Nasik, Ujjain and Hardwar. Over 120 million Hindus gather in each location at the banks of major rivers, including the Ganges and the Yumna in which pilgrims bathe as an act of worship on up to six important bathing days [9,13–15]. Worshippers assemble at each location over a three-month period during which time the festival is held, alternating at the different locations four times in every twelve-year cycle. Festivals go on for 55 days in total. The BBC has reported that on a single day up to 30 million worshippers have gathered simultaneously [13]. These mass gatherings dwarf Hajj, Islam's pinnacle of worship centered on Mecca, though both share the risk of human stampede [16].

Islam's Hajj however is the best studied of all mass gatherings and has driven much of the scientific enquiry into the modern mass gathering. As many as three and a half million Muslims from 187 countries around the world gather for what is considered the final pillar in Islam returning them to Islam's birthplace in order to perform Hajj. Hajj is a series of week-long religious rites retracing the Prophet Mohammed's final visit to Mecca during which he drew the lines of Islamic pilgrimage which still stand today and delivered his Final Sermon revealing the final verses of the Quran and sealing the foundations of Islamic belief. Even today, true to the Prophet Mohammed's final Hajj, the modern Hajj incorporates the Prophet Abraham's footsteps centuries before Islam's inception and the legends of Hagar, Ishmael, Adam and Eve.

With the rise in Muslim population the Hajj can be expected to grow in attendance and Saudi Arabia is preparing for these increased capacities investing in massive construction and infrastructure developments accordingly Saudi Arabia has committed \$100 billion in both land and infrastructure expansion with much of this work ongoing [16]. The King Abdul Aziz International Airport and the expansion of the Haram Sharif-the Grand Mosque surrounding the Ka'aba-is to be completed 2018/2019. 'Haramain' a high speed above ground railway linking Mina to Medina, the second holiest city in Islam (often included in Hajj rites) will be completed this year but opened to the public after extensive testing in 2018. The Mecca-Metro project connecting a four kilometer long station and two metro stations to the tune of \$16.5 billion will be completed by the decade's end, greatly relieving congestion at the focal site of Hajj.

6. Mass gatherings in the world of sport

Possibly the most beloved sporting events of all time are the Olympics inspired by the athletic games held in ancient Greece as far back as the 4th century BCE. The modern Olympics were conceived in 1894 with the formation of the International Olympic Committee which has governed every Olympics since the Games were first revived in 1896 [17].

Olympic Games draw mass gatherings. The London Olympics in 2012 drew 8 million in attendance paying high prices for tickets. The more controversial and beleaguered Rio Olympics for 2016 sold only 82% of the 5 million tickets available even though the tickets were significantly cheaper [18]. Regardless, the Olympics, whether Summer or Winter and its counterpart, the Special Olympics, draw millions in attendance to watch the pinnacle of elite amateur sports. Nation states win an intensely competitive bidding process to secure the event, which (like the FIFA World Cup) can define a nation and celebrate its culture. Hosting the Olympics is considered a rare privilege and nations, once winning the bid, work intensely during the seven-year lead time to the event to prepare both an appropriate legacy and also the necessary infrastructure for the events: Olympic Villages for the athletes, and the necessary response systems needed for health, security and disaster response. These are enormously costly events.

Perhaps it is the modern Olympic Games which have most inspired

the foundations of studying medicine during sporting events physicians as David S Jones noted physicians 'only slowly became interested' 'mostly in marathons' when the winner of the 1904 St. Louis Olympic Marathon required four physicians in attendance after the race, due both to heat exposure and the pre-competition strychnine he had taken for performance enhancement [17]. By 1920, medical examinations for athletes had become mandated and in 1924. The United States sent its first physician with its Olympic team to Paris. Slowly medicine began to interface with sports, igniting the field of sports medicine for the elite athlete. Almost a hundred years later, today all attendees-spectators and athletes alike-are known to be exposed to risks which could endanger health during these spectacular events and the science of mass gathering medicine has come into view informed by the experience of managing the public health at these huge events.

Equally prestigious and just as hotly contested is the FIFA World Cup held every four years. This year's FIFA World Cup in 2018 is being held in Russia, and the subsequent has been awarded to Qatar, in 2022. Interrupted only by World War Two, the World Cup has continued since its founding in 1930 held in Uruguay, which, even then, drew more than half a million attendees. The Brazil World Cup in 2014 drew 3.4 million attendees. In all more than 35 million people around the world have attended a World Cup event yet today in the televised era it commands audiences of billions [19]. The revenue generated by the FIFA world Cup is extraordinary -\$5.7 billion during Brazil 2014 -because of the cumulative television audiences watching all the matches and lucrative sponsorship deals – more than 26.29 billion watched the 2006 world cup [20]. Audiences can only be expected to be bigger in the era of live-streaming, enabling anyone with an internet connection to tune in, sometimes to watch games more than once. Because of its scale, the FIFA World Cup is the most viewed sporting event today.

Given its unique experience and unparalleled popularity, FIFA has contributed important understandings to the management of mass gatherings in both public health and public security aspects. Legacy building has been very critical to FIFA and is a deal-breaking aspect of each competitive bid, and often a focus of criticism after events.

7. Public health security at mass gatherings

The crowds at mass gatherings are a captive audience and vulnerable to environmental, physical, infectious and non-infectious hazards. They are also increasingly prime targets for terrorism including bioterrorism. Whether a sporting or religious gathering these risks are shared though their nature may vary [21–23].

8. Non-infectious hazards at mass gatherings

8.1. Stampedes

Both religious and sporting events can be at risk of stampedes which can evolve whenever crowds gather. While human stampede is lethal and devastating (forces of up to 4500 N/m can be generated by several people pushing in panic) with death resulting from acute venous hypertension, traumatic asphyxia, crush injuries to the torso and other catastrophic trauma, investigators in the field of human stampede note even in this modern era that there is a serious lack of high-level epidemiological data examining human stampedes.

As a result, both experts and casual observers are mistakenly influenced by unbalanced media focus which trains its scrutiny on Hajj each year and may be misled in believing it is the only mass gathering at risk of stampede, and the single most frequent site of human stampedes. Neither of these assumptions are true.

Hsu et al. searched both research and unconventional sources including media reports for evidence of human stampede incidents [24]. They found from 1980 to 2007, 215 distinct human stampede events resulting in 7069 deaths globally and 14,000 recorded injuries. The deadliest single human stampede in the past century occurred in

Baghdad in 2005 with 965 deaths reported during a religious procession. Hajj 2006 resulted in the human stampede at Mina Valley costing the lives of 380 pilgrims. Not until Hajj 2015 did Hajj see another human stampede sadly resulting in the loss of 769 pilgrims [25].

Certainly, of the top ten most lethal human stampedes, seven occurred at religious gatherings, not exclusively the Hajj but also other religious events. In India, 79% of all human stampedes occurred at religious festivals according to a recent exhaustive review [26,27].

Non-religious mass gatherings were also the site of human stampedes including political gatherings, sports events, entertainment venues and spontaneous gatherings. In Phnom Penh in 2010 a shopping stampede on Black Friday (usually implying major sales) resulted in 347 deaths [24].

But most human stampedes occurred not in the Arabian Peninsula –home of the Hajj- but in developing nations in Africa and Southern Asia. Together South Asia and Africa suffer over half of the world's human stampede. Yet each year, media coverage focuses intensely on Saudi Arabian Hajj sites (Mecca, Medina, Muzdalifah and Arafat) devoid of this context.

When stampedes occur in the developing world, mortality is more than eight-fold greater than when the stampede occurs in advanced societies like Saudi Arabia. This increased fatality is a result of lack of planning, inexperience with crowd management and crowd control, scant emergency services, limited trauma care and infield emergency services and limited onsite and first responder communication capabilities.

Saudi Arabia each year goes to intense effort to prevent stampede, one of many physical hazards associated with Hajj and as a result stampedes have been few and rare. Despite a spiritual reluctance to bar any eligible Muslim from Hajj, Saudi Arabia does limit Hajj attendees through global visa quotas. Also, once a local Muslim in KSA has been to Hajj, Hajj visas cannot be issued for the next five years limiting frequent performers of hajj. Yet the major improvements in Hajj crowd management have been through engineering: the multilevel bridge at Jamarat, site of the stoning ritual which has been a previous site of stampedes at Hajj; the re-engineering of the pillars at Mina into elliptical columns in place of cylindrical columns to dissipate crowd densities and reduce crowd turbulence from developing, and the development of massive pedestrian causeways which are color coded, one way, and temporally controlled to ensure steady throughput of pilgrims by controlling pilgrim ingress into these causeways through optimized schedules. Movement of the Hajj crowds in these areas of high density and high emotion –both risk factors for stampede- is monitored in real-time through video graphic analysis. Intervention can be implemented real-time, which can be both life- and limb-saving. Detailed video recordings achieved at Hajj examining crowd dynamics are primarily the means of assessing the flow of Hajj crowds. In the future, more sophisticated assessment is likely to be achieved in a number of additional ways-through fixed-laser scanning devices, closed circuit television and fixed GPS monitors [25,27].

While a much smaller scale, human stampede at a British football match has been more exhaustively examined than any other stampede in history. The Hillsborough Stadium stampede was among the most disastrous events in Football and examining its causes has been instructive if extremely painful for the football community and Britain in particular [28,29]. The 1989 FA Cup Semi-Final was held in the Hillsborough Stadium in Sheffield on April 15th, 1989 drawing two intense rivals- Liverpool and Nottingham Forest -for a contest place in the Final for the FA Cup – the biggest sporting event in British Football [30]. 24,000 Liverpool fans traveled to Sheffield for the event. Authorities knew of the rivalries between both teams and because of the propensity for vandalism and hooliganism among fans on both teams, their entry to the stadium was deliberately segregated, as were the ‘pens’ designated for fans of each team. Because of the bottleneck at the entrance and the large numbers of attendees, fans initially poured into two central ‘standing only’ pens-sections of the stadium demarcated by wire

barriers, unaware that to either side of them thousands of empty seats were available. No one directed the congregating crowds to these more lateral areas on the right and left. As the time for kick-off was only minutes away, the Chief Superintendent (the police commander in charge of the event) allowed an additional gate to open as lines of Liverpool supporters outside the stadium had built up. Unaware that in the central standing pens crowd density was already high, the surge of 2000 additional people resulted in 96 deaths-men women and children and more than 766 injuries. All except one were Liverpool fans. Hillsborough remains the worst disaster in British sporting history. In 2016, British Jurors, celebrating for 259 days (the longest inquest in British history)- emerged to convict the Chief Superintendent “responsible for manslaughter by gross negligence” due to a breach of his duty of care. The tragedy was compounded by the fact that the Hillsborough Match had been the first mass gathering under his command.

9. Mass gatherings and social behavior: help and hazard

9.1. Stampedes

While the Hajj crowds are massive, they must also be considered as fragile. Hajj draws Muslims of all ages from over 187 different nations. For many Muslims, this is their first and only overseas journey. Muslims at Hajj range in fitness, disability and span the entire lifespan from newborn to the very end of life. Muslims performing Hajj are awestruck at engaging in the highest form of Islamic worship and fulfilling what is often a life-long, dearly held aspiration.

This spiritual commitment which is of the utmost priority for them to complete Hajj to the best of their abilities adding to a religious intensity and focused commitment despite harsh and difficult physical conditions imposed on the pilgrim whether by climate or congestion often in the face of sleep deprivation and other forms of self-denial required in the spiritual state of the Hajjee.

Pilgrims are therefore vulnerable not only to their surroundings but to a fear of not completing Hajj. Stampedes are known to be triggered by fear, panic and as many investigators have noted, even by rumor. Live surveillance of Hajj crowds is vital to help pilgrims achieve their rites safely. Hajj authorities can assess mounting crowd densities, blockage of foot traffic, bottlenecks and dangerous nascent crowd turbulence which can precipitate human stampede. Supervision of the crowds at Hajj is unlike any other mass gathering in the world [25,27]. Interagency communication between various authorities overseeing the Hajj (Security forces, Civil Defense and special forces experienced in crowd control) and is continuous and announcements through public communication can be made if needed. SMS capable networks (instant messaging via cellphones) are also available and have been used for urgent health messaging to communicate to the vast numbers of attendees simultaneously.

9.2. Spiritual ethos

Because the Hajj is so trying and Muslims, enjoined by the Maker, remain so committed to completing it peacefully and without infringement or desecration of anyone else's efforts in pilgrimage, the Hajj crowd works informally together, shifting to accommodate the weak, the vulnerable, the disabled who are in the teeming crowds next to them. In this way Hajj, like other religious mass gatherings, is infused with a collective spirituality that can be of enormous public health benefit. Further, this spirit of protecting the entire Muslim community is clearly delineated in the teachings of Islam to be a metaphor for life beyond Hajj for all the world's Muslim community-a reminder that we must live together in harmony to peacefully collaborate and support one another through hardship and vulnerability. Additionally, these values greatly enhance the pilgrim populations' receptivity to public health planners and on site security in ensuring disaster management and crisis aversion can be achieved with as much cooperation as

possible.

9.3. Intoxication

Unlike religious gatherings, mass gatherings connected to sport or music events can be complicated by the availability of alcohol, recreational and illicit drugs, all of which impede the ability of an individual to remain safe within the mass gathering and impede the ability of the crowds to behave protectively towards the vulnerable [31]. These events are usually open air, often held in undesignated locations (particularly when considering electronic dance raves and may not benefit from experienced professional organizers). Sometimes events are held in underground locations which were never designed to accommodate such capacities. Participants are generally younger in age than those attending religious gatherings or the diverse ages seen in attendance of sports gatherings.

Music festivals, particularly the electronic dance movement event, are increasingly associated with intoxication and injuries [32]. Targeting young people aged 15 to 25 they draw large crowds, sometimes in unregulated venues, but increasingly today in purpose-built locations. Alcohol overuse and recreational drug use are commonly associated with these events. Both MDMA (3,4-Methylenedioxy-N-Methylamphetamine) and the notoriously named date rape drug (gamma hydroxybutyric acid) are liberally used at these events. Lund et al. report that in a fifteen year period 68 deaths were recorded of drug related overdose at Electronic Music Dance Events. Violence at such events has also been recorded with participants reporting stabbings – some severe enough to result in tube thoracostomy. Matters are worsened by the fact that many participants self report ‘preloading’ – drinking alcohol prior to entry to the event, a common practice at American events which can occur during ‘tailgating’ – when Americans often picnic around the trunk of their cars in the parking lots of the venues. While for most American families this means an innocent meal of hamburgers and hot dogs, for youngsters attending rave events this could mean ‘preloading’ particularly if attendees to the raves are under legal drinking age, adding to their vulnerability.

Excessive alcohol consumption with or without recreational drug use increases the risk of injury, sexually transmitted disease and extreme behaviors like the recently fire jumping and more traditional risks of sexual assault.

9.4. Fire jumping

While the focus of this paper has been primarily planned mass gatherings, mass gatherings can erupt spontaneously. One such phenomenon is the celebratory riot which can develop for instance when a sporting team wins a match or tournament. Hawkins et al. describe the spontaneous mass gathering of 52,000 fans which assembled when the University of North Carolina men's basketball team played in the National Collegiate Athletic Association, Final Four SemiFinal and National Championship games in St. Louis, Missouri in the United States [32]. As a result of the matches, back in the team's home state of North Carolina, two mass gatherings assembled on two consecutive nights drawing a total of 52,000 fans. Celebrating their team, they lit bonfires in the downtown area of Chapel Hill where they were congregating and began fire jumping – jumping and dancing through the flames by way of a victory dance. A total of 58 revelers needed medical care including 27 from the on-the-ground EMS responders and a total of 49 who needed emergency room admission. The average age of the injured was 23.8 years and they were predominantly male. Most – 65% – had medical complaints relating to alcohol and didn't need hospital admission. Of those who were admitted to hospital, one third had burns from firejumping.

These injuries are a function of the spontaneity and unplanned nature of these mass gatherings which unlike planned mass gatherings lack well defined boundaries. Revelers have no idea of how EMS will

reach them should the need arise, nor of the disruption to access, and public health demands by their incoherent mass activities. Further, such spontaneous gatherings are compounded by the use of excessive alcohol and illicit drugs. The crowds unlike a Catholic crowd at World Youth Day or a Muslim crowd at Hajj is widely diverse in their composition – while some revelers maybe hardcore hooligans or hoodlums others have never attended a mass gathering. The propensity for deliberate violence and even sexual assault can be created especially when vulnerable inexperienced attendees find themselves caught in the melee. Even the mood of the crowd-the collective mind-as earlier researchers referred to it-can vary from benign to malignant, from celebratory to actively destructive.

9.5. Sexual assault

Sexual assault can manifest in such circumstances. Perhaps one of the most extraordinary spontaneous mass gatherings of the last decade is now dubbed “Tahrir Square” first at the time of the Arab Spring reaching Egypt in February 2011 and later, in response to newly elected Mohammed Morsi being deposed by a military coup in July 2013. While no academic papers exist in the literature at the time of writing concerning sexual assault at Tahrir Square, the mainstream media reported extensively on sexual assaults impacting women protestors at Tahrir Square, shocking many in the region, particularly in the Muslim Majority world.

Sampsel et al. published the first reports of mass gathering associated sexual assault [33]. Important data reported by Sampsel et al. reveals that sexual assault occurs at mass gatherings peaking on specific holiday events- New Years Eve, Canada Day, Halloween and University Freshmans' week. Women were more often assaulted if they were of younger age, had consumed alcohol or drugs and unlike most sexual violence which befalls women aged 18 to 30, the assailant at mass gatherings was not previously known to the victim. More often than not, victims declined to release the findings of their ‘rape kit’ as evidence to the police in the hope of seeking prosecution. The sexual assaults at these mass gatherings occurred both within a friend's home and also outdoors, as in Tahrir square. Unlike sexual assaults occurring independent of mass gatherings, the majority of women did not know their assailants suggesting perpetrators may seek out mass gatherings as cover for predating sexual assault on vulnerable victims. Sampsel noted the increase in sexual assault events in conjunction with mass gatherings which fell on Canadian holidays and surmised that in this occasions the consumption of excess alcohol was more likely. Sexual assault transpires much more often when the victim has consumed excess alcohol often spiked with covert drugs in an effort to render the victim unconscious and unable to resist assault. These patterns support the view that the nature of the revelry, and the young female revelers assembling in this gatherings are additionally vulnerable because of social behaviors at such mass gatherings leading to drug facilitated sexual assault.

9.6. Mass gatherings and terrorism

Sixteen years post 9/11, it is impossible to consider mass gatherings independent of terrorism irrespective of their location. Because of both the magnitude of citizens gathering at mass gathering events whether for celebratory or spiritual purposes, the prize of disrupting a civilian event often garnering extraordinary mass media attention proves very tempting for nefarious actors [34]. Terrorists seek two goals: one to physically disrupt, kill and maim as many innocents simultaneously, and do so with maximum digitally transmitted reverberations to enhance the impact of their attacks. But they also act to instill fear and immobilization in the target population both at the event targeted, but more importantly in the desire to return to normal life. Mass gatherings present perfect targets for both these goals.

Vulnerable events include political, sporting, entertainment events-

political party conventions, sporting tournaments like the SuperBowl, the Olympics or the FIFA World Cup. US experts in homeland security remark that when events tie mass gatherings of the American public with specific national events of celebration – Independence Day Celebrations for example, or events honoring the military or the nation's patriotism threats are not only perceived to be tangible but escalating in risk.

Hazards that must be considered are diverse. Biological agents, ever since the Anthrax attacks immediately after 9/11 targeting government officials, remain a major concern. Many events-consider a Presidential Inauguration – are open air. Access is very difficult to limit and the dissemination of a biological agent over such massive crowds (exceeding a million people at President Obama's first inauguration) pose terrifying consequences, particularly if military grade biological weapons were released. One agent could kill hundreds or hundreds of thousands of people depending on its virulence and the dose released.

It is not inconceivable that sophisticated terrorists release a biological pathogen in a mass gathering of a population with no immunity to this agent. In 2003, homeland security notes that participants in an outdoor concert contracted Hepatitis A, causing morbidity among a population never vaccinated for this virus [34,35].

American cities hosting mass gathering events take this public health security threat very seriously. As far back as 2007, when Miami hosted the SuperBowl XLI bio-surveillance activities were expanded by three County health departments and the Florida State Department of Health. They were prepared to identify a bioterrorism attack which might have been invisible during the mass event but become apparent within a two-week window of the SuperBowl XLI. Because of the enhanced bio surveillance, public health officials identified more illnesses, injuries, accidents and absenteeism than usual. Most importantly, three different public health departments were able to successful data share and coordinate their responses to real-time findings.

The Federal Bureau of Investigation (FBI) is charged with identifying and generating intelligence about potential and actual terrorist attacks throughout the United States including attacks that can endanger mass gathering events. Critical to the success of advance warning for these events is a clear line of communication and excellent education of the FBI concerning mass gatherings. A key recommendation the US Committee on Homeland Security made was for the development of a National Medical Intelligence Program which would enable combined knowledge of public health concerning bioterrorism to be located within a knowledge base of domestic intelligence concerning potential actors.

Critical to all these events is the collaborative approach. Sharing resources across sectors and agencies whether public or private entities is critical to mass gatherings being safe-guarded. Without such collaboration, agencies may compete with one another and hoard information, jeopardizing not only the mass gathering event but also the host city which may well swell in population to become transiently some of the largest cities in the country for the duration of the mass gathering event.

9.7. Global Health Security Agenda for all mass gatherings

Global health security is a relatively novel concept: galvanizing public health responses to threats which could imperil the global community. Most recently three pathogens have captured the imagination driving the movement to formalize a Global Health Security Agenda-literally a world prioritization of threats to public health security [17]. The Ebola Virus epidemic, the influenza pandemic and the MERS- Corona Virus outbreaks in the Arabian Peninsula and South East Asia all demonstrated the need for urgent coordinated international responses to avert devastating international impact. Periodically health ministers from around the world meet to set the Global Health Security Agenda and streamline a multidisciplinary and coherent response to contain these threats.

While a Global Health Security Agenda for mass gatherings has not been proposed, Saudi Arabia, in its experience of managing the Hajj recognized at the inaugural meeting on Mass Gathering Medicine in Jeddah 2010 formalized the discipline of mass gathering medicine. Six years on, it is time the mass gathering community call for proposals to set a Global Health Security Agenda for planned mass gatherings around the world. Certainly, yellow fever while not yet a global threat, is a serious consideration for all mass gatherings receiving international visitors.

Certainly, each country hosting a mass gathering, whether religious or sporting, must enact surveillance and disease reporting mechanisms during the mass gathering events themselves to be able to identify case clusters or even infectious disease outbreaks. Control measures and means to prevent these infections being exported back by the attendees to the attendees' countries of origin must be in place. Countries receiving participants in events whether a religious pilgrimage or a mass sporting event must be ready with a public health surge capacity to respond to returning travelers especially at a time of heightened awareness of outbreak potential. Surge capacity is especially important if host country's health systems are not to be depleted or placed under undue strain during mass gathering events.

Conflicts of interest

Both authors declare no conflict of interest.

References

- [1] <http://www.english-heritage.org.uk/visit/places/stonehenge/history/> Accessed Feb 11, 2018.
- [2] Wolfe Michael, editor. One thousand roads to Mecca: ten centuries of travelers writing about the Muslim pilgrimage paperback. September 22, 1998 <https://www.amazon.com/One-Thousand-Roads-Mecca-Pilgrimage/dp/0802135994>.
- [3] <https://www.poetryfoundation.org/poems-and-poets/poems/detail/44299> Accessed Dec 23 2017.
- [4] The Myth of the Madding Crowd (Social Institutions and Social Change) by Clark McPhail (Author). <https://www.amazon.com/Madding-Crowd-Social-Institutions-Change/dp/0202303756>.
- [5] Hopkins N, Reicher S. The psychology of health and wellbeing in mass gatherings: a review and a research agenda. *J Epidemiol Glob Health* 2016;6(2):49e57.
- [6] Bala MO, Chehab MA, Selim NAA. Qatar steps up to Global Health security: a reflection on the joint external evaluation, 2016 vol. 18. *Glob Health Res Policy*; 2017 Oct. 2:30.
- [7] <http://www.pewforum.org/2012/12/18/global-religious-landscape-exec/> Accessed 29 Oct 2017.
- [8] Gautret P. Religious mass gatherings: connecting people and infectious agents. *Clin Microbiol Infect* 2015;21:107–8.
- [9] Sridhar S, Gautret P, Brouqui P. A comprehensive review of the Kumbh Mela: identifying risks for spread of infectious diseases. *Clin Microbiol* 2015;21:128–33.
- [10] Staff M, Torres MI. An influenza outbreak among pilgrims sleeping at a school without purpose built overnight accommodation facilities. *Commun Dis Intell Q Rep* 2011 Mar;35(1):10–5.
- [11] <http://www.aljazeera.com/news/asia-pacific/2015/01/million-join-parade-jesucan-manila-20151973625966141.html> Accessed Oct 29 2017.
- [12] Lillie AK. The practice of pilgrimage in palliative care: a case study of Lourdes. *Int J Palliat Nurs* 2005 May;11(5):234–9.
- [13] <http://www.bbc.com/news/world-asia-india-21395425> Accessed 29 Oct 2016.
- [14] Jani K, Dhotre D, Bandal J, Shouche Y, Suryavanshi M, Rale V, Sharma A. World's largest mass bathing event influences the bacterial communities of Godavari, a holy river of India. *Microb Ecol* 2018 Mar 13. <http://dx.doi.org/10.1007/s00248-018-1169-1>. [Epub ahead of print].
- [15] Kazi DS, Greenough PG, Madhok R, Heerboth A, Shaikh A, Leaning J, Balsari S. Using mobile technology to optimize disease surveillance and healthcare delivery at mass gatherings: a case study from India's Kumbh Mela. *J Public Health* 2017 Sep 1;39(3):616–24.
- [16] Ahmed QA, Hajj Memish ZA. Safeguarding the faithful - Saudi Arabia takes the long view. *J Health Spec* 2016;4(4):227–9. 2016.
- [17] Jones DS. Olympic medicine. *N Engl J Med* 2012 Jul 26;367(4):289–92.
- [18] <http://fortune.com/2016/08/07/rio-olympics-ticket-sales/> Accessed 10/29/2017.
- [19] https://en.wikipedia.org/wiki/2014_FIFA_World_Cup Accessed 10/29/2017.
- [20] <http://www.fifa.com/about-fifa/news/y=2007/m=2/news=2006-fifa-world-cuptm-broadcast-wider-longer-and-farther-than-ever-bef-111247.html> Accessed 10/29/2017.
- [21] Dvorak J, Junge A. Twenty years of the FIFA Medical Assessment and Research Centre: from 'medicine for football' to 'football for health'. *Br J Sports Med* 2015 May;49(9):561–3.
- [22] Ahmed QA, Barbeschi M, Memish ZA. The quest for public health security at Hajj:

- the WHO guidelines on communicable disease alert and response during mass gatherings. *Trav Med Infect Dis* 2009 Jul;7(4):226–30.
- [23] Elachola H, Assiri A, Turkestani AH, Sow SS, Petersen E, Al-Tawfiq JA, Memish ZA. Advancing the global health security agenda in light of the 2015 annual Hajj pilgrimage and other mass gatherings. *Int J Infect Dis* 2015;40:133–4.
- [24] Hsu EB, Burkle FM. Cambodian Bon Om Touk stampede highlights preventable tragedy. *Prehospital Disaster Med* 2012 Oct;27(5):481–2.
- [25] Alaska YA, Aldawas AD, Algerian NA, Memish ZA, Suner S. The impact of crowd control measures on the occurrence of stampedes during Mass Gatherings: the Hajj experience. *Trav Med Infect Dis* 2017 Jan - Feb;15:67–70.
- [26] Illiyas FT, Mani SK, Pradeepkumar AP, Mohan K. Human stampedes during religious festivals: a comparative review of mass gathering emergencies in India. *Int J Dis Risk Reduct* 2013;5:10–8.
- [27] Johansson A, Batty M, Hayashi K, Al Bar O, Marcozzi D, Memish ZA. Crowd and environmental management during mass gatherings. *Lancet Infect Dis* 2012 Feb;12(2):150–6.
- [28] Wardrope J, Ryan F, Clark G, Venables G, Crosby AC, Redgrave P. The Hillsborough tragedy. *BMJ* 1991 Nov 30;303(6814):1381–5.
- [29] <http://www.bbc.com/news/uk-19545126> Accessed Oct 30 2016.
- [30] <http://www.bbc.com/news/uk-england-merseyside-35383110> Accessed Oct 30 2017.
- [31] Lund A, Turris SA. Mass-gathering medicine: risks and patient presentations at a 2-day electronic dance music event. *Prehospital Disaster Med* 2015;30(3):1–8.
- [32] Hawkins ER, Brice JH. Fire jumpers: description of burns and traumatic injuries from a spontaneous mass gathering and celebratory riot. *J Emerg Med* 2010 Feb;38(2):182–7.
- [33] Sampsel K, Godbout J, Leach T, Taljaard M, Calder L. Characteristics associated with sexual assaults at mass gatherings. *Emerg Med J* 2016 Feb;33(2):139–43.
- [34] Committee on Homeland Security. Majority staff report examining: public health, safety, and security for mass gatherings. May 2008.
- [35] <http://www.cdc.gov/mmwr/preview/mmwrhtml/mm5235a5.htm>.