Original Article

Public health aspects of the world's largest mass gathering: The 2013 Kumbh Mela in Allahabad, India

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Abstract India's Kumbh Mela remains the world's largest and longest mass gathering. The 2013 event, where participants undertook a ritual bath, hosted over 70 million Hindu pilgrims during 55 days on a 1936 hectare flood plain at the confluence of the Yamuna and Ganga Rivers. On the holiest bathing days, the population surged. Unlike other religious, cultural, and sports mass gatherings, the Kumbh Mela's administration cannot estimate or limit the participant number. The event created serious and uncommon public health challenges: initiating crowd safety measures where population density and mobility directly contact flowing bodies of water; providing water, sanitation, and hygiene to a population that frequently defecates in the open; and establishing disease surveillance and resource use measures within a temporary health delivery system. We review the world's largest gathering by observing first-hand the public health challenges, plus the preparations for and responses to them. We recommend ways to improve preparedness.

Journal of Public Health Policy (2016) **37**, 411–427.
doi:10.1057/s41271-016-0034-z; published online, 8 September 2016

Keywords: mass gathering; crowd control; water supply; sanitation; hygiene; epidemic surveillance

Background

From January to March 2013, the Kumbh Mela, a Hindu religious festival held in Allahabad, India, hosted over 70 million people, making it the largest and longest mass gathering in human history.[1–3] Mass gatherings, defined as transient congregations of large numbers of people, often exceed the capacity of routine health and safety measures, and consequently require the resources, organization, and commitment to provide for a wide range of eventualities, including epidemics, stampedes, spontaneous violence, and terror strikes.[4] In keeping with the growing demand to share and learn from the 'legacy' of mass gatherings, we undertook an in-depth exploration of the variety and vastness of the public health needs presented by the world's largest and longest human gathering.[5,6]

While other religious gatherings, like the Hajj, sporting events like the Olympics, or the world's largest music festival, the Donauinselfest, are attended by large international audiences, the Kumbh Mela is largely a domestic event. Yet, lessons learnt from successes and failures of crowd mitigation; water, sanitation, and hygiene preparedness; and health service delivery at the Kumbh Mela can find wide application in other mass gatherings and in large transient agglomerations like refugee camps and disaster-affected population migrations. In an increasingly interconnected world, given the small but growing number of international travelers visiting the Kumbh Mela, public health emergencies at this event can have far reaching consequences. Previous Kumbh Melas have been marred by stampedes and by cholera outbreaks that occasionally reached pandemic proportion.[7]

We were the public health component of a multidisciplinary group of academicians who studied various aspects of the Kumbh Mela in the domains of religion, architecture and urban planning, commerce, and public health. The public health team focused on crowd control, water supply, sanitation, hygiene, and epidemic surveillance. Our findings derive from archival research, from interviews with senior Kumbh Mela administrators before, during, and after the festival, and from direct observation throughout the 55 day-event.

Public Health Preparedness

The Kumbh Mela

The Kumbh Mela, or in Hindi, the 'kumbh fair,' is held once every 3 years in one of the four cities of Ujjain, Nasik, Haridwar, and Allahabad, each in a 12-year cycle.[8] The Allahabad event, considered the holiest of the four venues, draws tens of millions from across India. Attendees believe that bathing at the confluence, or *Sangam*, of the Ganga, Yamuna, and extinct Saraswati rivers will help them achieve "liberation" from the cycle of death and rebirth.

Every day thousands of pilgrims attended the 2013 Allahabad Kumbh Mela. They partook in religious discourses, cultural events, and communal meals. They sought the ritual dip at the Sangam. On the six holiest bathing days of the festival, their numbers rose by the millions. Unlike many organized mass gatherings, no precise means or methods existed by which to predict or control the size of the crowds or to anticipate attendance on any given day. Inability to predict surge dynamics created immense challenges while preparing to ensure public safety.

A pop-up township

To accommodate the visiting millions, the Indian government constructed a 1936-hectare (19.4 km^2) temporary town, or *Nagri*, on the riverbanks flanking the Sangam. Because construction on the sandbanks can only begin after the rivers have receded following the monsoon season (Figures 1A, B), the entire township was developed in less than three months. The Kumbh Nagri was replete with trappings of any modern city: roads, shelter, water, sanitation, commerce, and cultural spaces. Its fourteen administrative sectors were equipped with health clinics, police stations, food stalls, shops, and lost-and-found services. The administration also allocated compounds to religious orders, or *Akharas*, so they might host the thousands of holy men who attended the festival, and to provide their disciples congregational space for cultural events and communal meals.

The state government appointed the festival's principal administrative coordinator, the Mela Adhikari, a year in advance; he was responsible for all planning and execution. In 2013, his administration laid 156 km of steel-plated roads, constructed 18 pontoon bridges, installed 980 km of electricity wires, and managed a budget of over

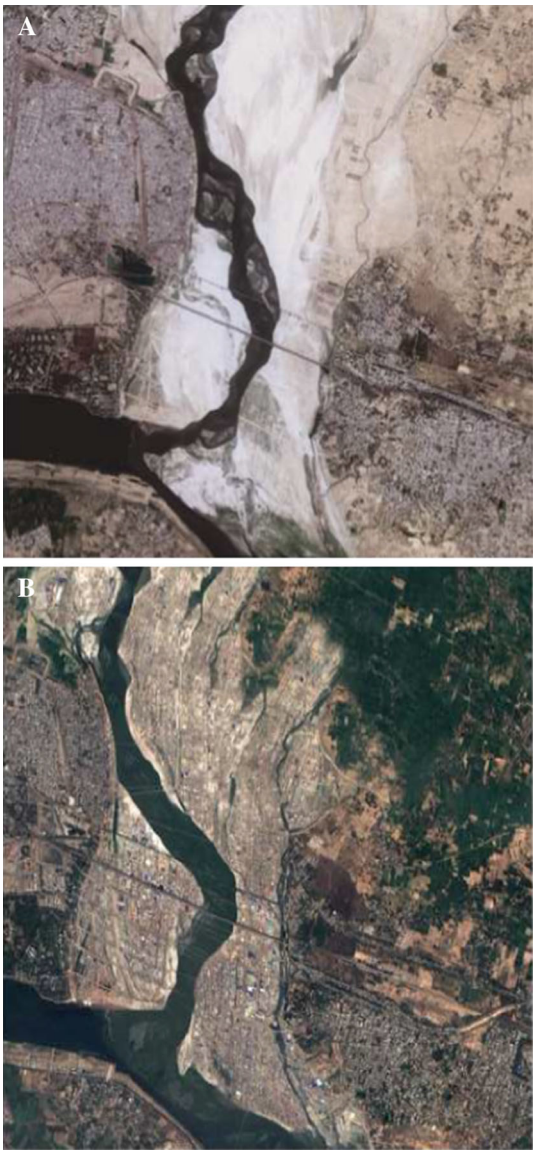

Figure 1: A. Aerial image of the Kumbh Nagri site on Jun 29 2012 (Google Maps). Note the barren exposed sandbanks and floodplain during the preceding monsoon season, site of the future pop-up megacity. B. Aerial image of the fully constructed Kumbh Nagri, on February 7, 2013 (Google Maps).

$200 million.[9] Given the time between events, there was little continuity in the administrative structure or personnel since the last Allahabad Kumbh Mela. In the absence of written operational codes, the construction team relied heavily on institutional memory captured in archival government reports and on the experiences of the few employees who have served at previous Kumbh Melas.[10] A web of partnerships between the state, private businesses, and religious orders offered services for the event. Communication between stakeholders followed a hierarchical, bureaucratic chain of command. Real-time information during the festival flowed very slowly across these complex networks.

Crowd safety

Stampedes have plagued the Kumbh Mela over the last century.[11] In 1954, a rogue elephant escaped into a dense crowd that had gathered for a glimpse of the visiting prime minister. This triggered a stampede that killed 500 pilgrims. The resultant widespread criticism of the state has ensured that successive Kumbh Mela administrations have made crowd safety a priority.[8]

The Mela Adhikari tasked the Kumbh Mela police force with crowd management. Through years of observing the behavior of the Kumbh Mela pilgrims, the police had devised safety measures to mitigate stampedes. In 2013, the police took into account characteristics and habits of individual pedestrians and trained on the macroscopic self-organizing principles of crowds, which together influence pedestrian dynamics.[12]

Most visitors stayed only a short time at the Kumbh Mela, although they traveled long distances carrying their luggage with them. They typically packed their belongings into a single bag that was slung over the shoulder, or carried on the head. They mostly traveled in groups, either belonging to the same village or religious sect. Despite the vast range of events and the varying lengths of attendance, most of the pilgrims came primarily for their ritual holy dip at the Sangam.

In addition to the millions who reached the Sangam on foot, thousands traveled there in large religious processions, comprised of chariots, cars, and trucks. Pilgrims, traveling in groups, tended to stay close to the Sangam: after their bath, women dried out their sarees (wrapped garments) before leaving on their return journeys; families sat

together to pray or share a meal. Consequently, the space adjacent to the confluence was maintained as a wide open 'staging area,' where millions of pilgrims assembled, waiting their turn to enter the water, or rest afterward (Figure 2).

Pilgrims reached the staging area from the rest of the Nagri by an extensive network of roads constructed by flattening and covering the riverbed with metal plates. The roads, some sixty feet wide, were laid in a grid pattern and connected by a parallel array of multiple 'pontoon' bridges (see Figure 3) that allowed uninterrupted flow across its principal thoroughfares, from one riverbank to the other. This remarkably sound town planning choice is similar to that in other major river cities like New York or London, where a multitude of aligned bridges (and tunnels) facilitate high volume one-directional flow traffic across the riverbanks. The temporary bridges, comprised of 1400 locally commissioned floating pontoons, were strong enough to withstand the weight of tens of thousands of pilgrims and vehicles that traversed them. On busy bathing days, almost all pedestrian and vehicular traffic was unidirectional. Police staggered incoming crowds by rerouting them through a labyrinthine maze of roads before reaching the Sangam. On most days, the crowds moved smoothly. But

Figure 2: The 'staging area' on 10 February 2013, when the government reported 30 million visits at the Sangam.
Credit: Satchit Balsari.

Figure 3: Pontoon bridges packed with hundreds of thousands of pilgrims making their way to the Sangam.
Credit: Dhruv Kazi.

as the numbers surged by millions, the crowds increased their density and lost speed. The 60-foot wide roads narrowed to the 12-foot wide pontoon bridges, creating dangerous bottlenecks–the very phenomena the multiple bridges were meant to avoid. To control foot traffic and avoid overloading the bridges, police erected temporary barricades at the entrance ramps. While the barricades helped ensure bridge safety, they directly contributed to the creation of dense, impatient throngs that periodically burst onto the bridge in pulsating ebbs and flows. Baton-armed police stood ready to regulate these undulations of flow and prevent stampedes at the bridge bottlenecks.

Waterfront safety

Given the large number of pilgrims, including the frail and the elderly entering the water simultaneously, the risk of drowning accidents or a stampede at the water's edge was notable. To reduce erosion and prevent slips and falls on the congested waterfront, the riverbanks were covered in several inches of hay (periodically replaced throughout the Kumbh Mela). Closer to the water's edge, the hay was replaced by over 300,000 sandbags that provided a sturdy and gentle slope for visitors to enter the water. The shallow bathing areas were well demarcated by a perimeter of bamboo poles beyond which stood a row of lifeguards in boats and poised to respond immediately to water mishaps. The

administration optimized water flow by regulating a series of upstream dams to maintain a flow rate of 2500 ft^3/second — slow enough to maintain safety — but brisk enough to prevent water stagnation. No drowning accidents occurred at the 2013 Kumbh Mela.

Stampede at the 2013 Kumbh Mela

February 10, 2013 was *Mauni Amavaysa*, considered the holiest of bathing days. By evening, soon after the authorities had announced the successful completion of 30 million visits at the Sangam, overcrowding on an overhead footbridge at the nearby Allahabad railway station resulted in a stampede. The stampede, caused by a bi-directional rush of throngs of tired pilgrims navigating densely packed railway platforms to catch a departing train, resulted in 36 dead and twice as many injured. Transporting the injured to the tertiary hospital to receive definitive care was greatly delayed.

Closer examination revealed that the stampede resulted from bureaucracies failing to communicate, not just an unfortunate accident as portrayed by the media.[13] The federally administered railway ministry did not heed the state police force's request for more trains on February 10th. The preparatory crowd modeling exercises conducted by Kumbh Mela security were not synchronized across jurisdictions, precluding any crowd motion studies to trace the pilgrims' journey from the locally administered Nagri premises to the federally maintained railway properties. Lack of central coordination and delayed medical care exposed the absence of an on-site incident command structure. A long history of stampedes at Indian religious gatherings revealed similar observations.[14,15]

Water, sanitation, and hygiene

The Kumbh Mela's long history of cholera outbreaks dates back to 1783.[16] The human density, potential length of exposure time, and indigenous behaviors at the Kumbh Mela made for rapid transmission of disease. Thousands of pilgrims partook daily in communal meals, and tens of thousands bathed in the Sangam, often drinking some of the holy water for purification. Fecal contamination and water-borne disease transmission were persistent threats to attendees' health. To minimize these risks, the administration invested heavily in water and sanitation infrastructure.

At the 2013 Kumbh Mela, organizers provided potable water through an extensive network of 40 tube-wells and 20,000 taps, connected by 550 km of pipe that distributed 90 million liters daily. Given the pervasive bathing rituals, the administration took several steps to also improve the quality of the river water, with a focus on both microbiological and chemical wastes. The city of Allahabad doubled its sewage treatment capacity in time for the Kumbh Mela. Upstream distilleries, sugar-mills, and tanneries were required to run their water treatment facilities at maximum capacity for the duration of the Kumbh Mela, and prohibited from dumping any effluent into the river. This aggressive sewage control, combined with the optimized water current at the Sangam, probably resulted in the lower-than-expected coliform counts upstream and downstream from the Sangam. Random samples collected from many drinking water taps across the Nagri showed no coliforms.[17]

The administration provided 35,000 toilets for the pilgrims, mostly simple open-air pit latrines and urinals separated by cloth partitions, along with 340 tin sheds each of which enclosed ten squatting plates, and 68 modern bio-digested complexes which used "zero waste" technology.[18] Most of the rural population attending the Kumbh Mela do not have access to sanitation facilities at home, preferring open defecation fields to enclosed toilets. Acknowledging this, the administration employed 7000 "night-soil" sweepers around the clock to sweep up feces and cover open defecation areas with lime. The public works department engaged in an aggressive vector control campaign through widespread and regular spraying of DDT and malathion on areas of standing water, especially gray-water holding ponds.

Hand hygiene remained a persistent challenge and raised concerns about rapid fecal-oral transmission especially at large communal meals (Figure 4). While hand sanitizers were mounted at toilet facilities, most were stolen. At the 2013 Kumbh Mela, local soap brand, Lifebuoy, launched a clever advertising campaign that served as a powerful public health messaging tool: they branded one million rotis (flat breads) with the message, in Hindi, "Have you washed your hands with Lifebuoy today?" Generally, however, personal hygiene messaging was neither pervasive nor well-targeted. Given the range of literacy among the attendees, effective targeting of sanitation and hygiene messages should have used multiple strategies, including public announcements, posters, and reminders at the communal meals.

Figure 4: Pilgrims gathered twice daily for free communal meals offered at the *akharas*. While hand hygiene remains poor in large swathes of the population, the communal meals offer a captive audience for targeting public health messaging.
Credit: Dhruv Kazi.

Health care

The state government invested in a large temporary 'hub and spoke' healthcare system situated entirely within the Nagri. A central referral hospital was the system's nucleus, while fourteen peripheral 'sector' hospitals provided primary and urgent care services.

Each sector hospital consisted of an outpatient clinic with an on-site pharmacy, and a 20-bed inpatient unit. Built close to the main thoroughfares and open to all comers, the sector hospitals saw hundreds of patients daily, almost all ambulatory. A physician, two nurses, and a pharmacist staffed each sector hospital, working 8-hour shifts around the clock. Sicker patients were up-triaged to the central hospital, a 100-bed inpatient unit with limited critical care capacity and multiple specialty outpatient clinics, including pediatrics, radiology, gynecology, cardiology, orthopedics, and otorhinolaryngology.

On busy bathing days, the number of patients presenting to sector hospitals closest to the main thoroughfares and the Sangam rose exponentially, several times the number presenting to the other hospitals. Without reallocation of resources to match this greatly increased demand, the duration of each patient encounter was drastically reduced. On February 10, doctors at the busy sector

hospitals saw an average of 500 patients each in an 8-hour shift. In total, from 25 January to 25 February, the fifteen hospitals logged 280,755 patient encounters.

The on-site pharmacists dispensed a free three-day supply of medications to the patients; the patients were allowed to return to the clinic for refills. The high throughput resulted in a staggering quantity of medications being dispensed without recording vital signs, conducting a physical exam, or following treatment protocols. Most presentations were of low severity and managed symptomatically with some combination of anti-pyretics, analgesics, and antibiotics.[19]

The state conscripted ambulances from its facilities across Uttar Pradesh and equipped them with field response supplies plus special kits for burns and stampedes. Most of the 143 ambulances drafted in 2013 lacked trained paramedics, had inaccessible (under lock and key) on-board resuscitation equipment, and faced long response delays on the busy days when heavy pedestrian traffic surrounded them (Figure 5).

Health providers maintained hand-written medical records. Physicians recorded each encounter in a notebook, including the patient's

Figure 5: Heavy pedestrian traffic surrounds an ambulance at the Kumbh Mela. On busy bathing days, it took the ambulance several hours to traverse the few kilometers leading out of the Nagri. *Credit*: Dhruv Kazi.

name, age, gender, chief complaint (which also served as the diagnosis), and medicines prescribed. Each sector hospital reported its daily census to the central hospital every evening. During high patient volumes, the record keeping became nearly nonexistent, and the resultant data gaps precluded systematic analysis to inform time-sensitive decisions about resource use. Further, despite being a critical priority in other global mass gatherings, no surveillance system that would detect outbreaks or inform a response was in place at the start of the event.[20]

Recommendations and Conclusions

The government's role in the Kumbh Mela has, over the centuries, evolved into active engagement with population safety and health. The administration's experience with implementing large-scale but relatively low-cost solutions to address risks of stampedes, drownings, and disease outbreaks offer valuable lessons for dense urban environments, including other mass gatherings, urban informal settlements, and refugee shelters. Yet, there is room to do more.

The government and the media widely reported that 100 million pilgrims attended the event.[21] While likely a high estimate, even the conservative estimate of 70-80 million means that close to six percent of India's population passed through the Kumbh Mela in 2013. Exposure to this slice of the population from across the country offers an unparalleled opportunity for wide-scale public health messaging and interventions.

One might argue that the healthcare provided at this open religious fair far exceeds the state's responsibility and to expect more might well result in placing unrealistic demands on the public sector. The current elaborate healthcare system ends up providing symptomatic pharmaceutical-based management for low acuity conditions. Diverting these resources to awareness campaigns, vaccinations, disease surveillance, and even diagnostic screening might improve public health. Given the persistent burden of tuberculosis, and the emergence of extensively drug-resistant TB in India, for example, the Kumbh Mela clinics provide an opportunity to screen patients presenting with a cough and fever, and then refer suspected cases to well-established tuberculosis programs across urban and rural India.[22] The clinics could also screen for diabetes and hypertension, both rising in India, under-diagnosed

and poorly managed. Portable wireless record transmission and rapid diagnostic aids would make such large-scale screening feasible. Communal meals, religious discourses, and entertainment venues at the Akharas provide ample opportunities to disseminate important health messages to a captive and receptive audience, especially as the Indian government tackles the rural problem of open defecation and potable water and sanitation access.[23]

Public health messaging about ingesting the river water is a case in point. While encouraging hand washing before eating flatbread is ingenious, cost-efficient, and not generally offensive, stepping into a sacred cultural phenomenon will require a thoughtful anthropologic strategy. So too will coaxing those who openly defecate to embrace pit latrines or biodigesters. These educational public health challenges must go beyond the Kumbh Mela itself by linking with similar community and national initiatives — community led total sanitation, and Prime Minister Modi's 5-year Open Defecation Free challenge, for example — and then regenerating that message during the festival to ensure continuity with the global effort.

The Kumbh Mela's festival atmosphere lends itself to important incentives for users of new sanitation technology, beyond the benefits of privacy, security, 'green' technology, and personal health. That said, no one will be motivated to use such sanitation facilities on crowded bathing days when the participant to toilet ratio can be 750:1. As such, the 2013 Kumbh Mela administration identified the water and sanitation's systemic failures during crowd surges as a critical future challenge.

India's near ubiquitous cell phone ownership provides opportunities for public health messaging as well as for understanding crowd behaviors and population movements. Adopting information technologies could assist better disaster management. Effective crowd surveillance technologies and rapid population estimates, as adopted at the Hajj or the Olympics, are conspicuously absent at the Kumbh Mela.[24,25] Remote sensing to determine crowd size is a first step in addressing crowd safety and providing early warnings in real time.

Spatial–temporal density analytics would especially benefit this festival in which no mechanisms are in place to determine participant numbers in advance and the population peaks and ebbs around the holiest bathing days. Thermal video sequence monitoring that uses algorithms to capture acute behavior changes within a crowd has the potential to continuously inform on crowd density and flow, and

enhance an early warning security decision support system that could determine the need to deploy critical first responders and ambulance movement at critical moments.[26]

While enhancing crowd surveillance technology would advance the Kumbh Mela's early warning and prevention, this must be in tandem with ground operations. On the bathing days, the inability of ambulances and rescue workers to enter and leave on land, in areas away from bathing sites, must be addressed. This would entail designated lanes only for emergency use that would connect at points along the network of roads for participant movement. Ideally these lanes would provide access to the central hospital that should have a readily deployable mass casualty incident command structure in place and in synch with higher levels of care in Allahabad.

Digitizing records of patient encounters would allow for real-time analysis to support outbreak surveillance and resource use and management. The current paper-based registries at sector clinics could not keep up with the volume and detail of patient interactions. We deployed handheld tablets with predesigned user interfaces at four sector hospitals.[27,28] The device's drop-down menus and radio buttons could rapidly identify patients with syndromic case definitions. We sent the captured data to a cloud database for rapid tracking, providing a tool for prospective outbreak surveillance. The device could also document patient encounters and treatments, allowing the health administration to track resources. Future iterations of this technology could include evidence-based treatment protocols for common chief complaints, preventing inappropriate and over-prescribing practice. The demonstration of an inexpensive communication and data management technology provides future Kumbh Mela health administrations with a deployable data-driven option for health care delivery and public health prevention and response.

Organizers for the next Kumbh Melas may greatly benefit from lessons learnt at previous Kumbh Melas. Future qualitative studies that focus on the most feasible and effective way to advance these recommendations can influence participant behavior and gain buy-in from Kumbh Mela administrative and implementing stakeholders.

Although the administration has proven extremely effective, breaking down the hierarchical nature of the bureaucracy remains a particular challenge. Adopting a reporting structure modeled along that of incidence command systems employed in disasters may help

streamline communications among participating agencies. Electronic record keeping may help improve efficiency and accountability. Reallocating health resources to support strategic preventive medical interventions may prove to be more cost-efficient than the current model of misappropriating medications for nonacute conditions. As India continues its rapid urbanization, middle-class expansion, and population growth, the burden of infectious and noncommunicable diseases, trauma, and violence endures and grows. Meeting this burden at the Kumbh Mela may require bold, indigenous and unorthodox solutions — the kind of solutions that already mark its success.

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