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| **Authors** | **Country** | **Variables** | **Descriptions** |
| Alquthami, A.H. 23 | Review | * Attendance * Weather * Availability of alcohol or drugs * Cold weather | During large events, there were paradoxically low presentation rates; Single-day events can utilize as many resources, if not more, as some multi-day events. |
| Anikeeva, O.L.6 | Australia | * Attendance * Crowd density * Venue * Event type * Mobility * Weather * Availability of alcohol or drugs * Wind speed | Type of event attracts different types of crowds and encourages certain behaviours. Higher presentation observed at events where alcohol is readily available. Events where attendees are predominately seat, such as sporting matches, generally have a lower incidence of injuries among attendees than events with a predominantly mobile crowd. |
| Arbon, P.5 | Australia | * Attendance * Crowd density * Venue * Event type * Mobility * Weather * Availability of alcohol or drugs | Several of the key characteristics incorporated into the Proximity Model have been researched extensively, and there is strong evidence for the relationships between these elements and the PPR. These include: (1) the effect of the type of event; (2) crowd size; and (3) weather conditions on PPR. Each domain will interact with the others and produce effects that can be measured in patient presentations and types of illness and injury. |
| Arbon, P. 35 | Australia | * Attendance * Venue * Event type * Mobility * Weather * Availability of alcohol or drugs * Historical data | A model to explain the different PPRs of similar size mass gatherings includes the following parameters: weather, alcohol use, availability of care, the event nature, injury or illness type, crowd mood, and others (eg, age of the audience). Additionally, regression models predicting the rates of patient presentation and transport to hospital have been developed based on the geographic nature of the event (bounded or unbounded-indoor or outdoor), weather, time of day, crowd size, and crowd mobility. |
| Arbon, P. 3 | Review | * Attendance * Crowd density * Event type * Mobility * Weather * Availability of alcohol or drugs | Key characteristics are weather (temperature and humidity), duration of event, outdoors or indoors, is crowd seated or mobile within venue, is it bound (fenced), type of event, mood (availability of alcohol and drugs), crowd density (geography of the venue terrain/locale, and average age of crowd. |
| Arbon, P.36 | Australia | * Attendance * Crowd density * Weather * Event type * Crowd demographics * Focused or extended * Availability of alcohol or drugs | The developed models were less useful for predicting patient presentation numbers for very large events; however, they were generally useful for more typical, smaller scale community events. |
| Baird, M.B.7 | Review | * Attendance * Venue * Event type * Weather * Availability of alcohol or drugs * Presence of ethanol * Time of day/week * Historical data * Dew point * Cold weather | Heat index seems to be the most promising weather variable for use in a simple universal prediction model. When planning for a specific event, data from similar events will provide more accurate info than a prediction model. |
| Burdick, T.E.15 | Australia | * Venue * Event type * Weather * Altitude * Precipitation * Cold weather | Injury and illness rates in specific wilderness activities are commonly on the order of 1 −10 per 1000 person-days, but may range from 0.2 to 1000 per 1000 person-days, with higher rates in competitive activities. |
| DeMott, J.M.32 | USA | * Event type * Availability of alcohol or drugs | The results showed that patients presented most commonly from large outdoor music festivals, were single, young, and had minimal past medical history with a high frequency of self-reported alcohol and illicit drug use. |
| Enock, K.E.24 | Review | * Attendance * Mobility * Weather * Availability of alcohol or drugs * Availability of free water * Cold weather | In Atlanta, the surveillance system used two categories of heat-related illness: ‘heat (skin/sunburn)’ and ‘heat (exhaustion/stroke)’. This information allowed public health officials to increase public awareness announcements at these venues, encouraging spectators to drink more fluids, seek shade and recognize the symptoms of heat-related illness. |
| Feldman, L.Y.12 | Canada | * Attendance * Weather * Air quality * Historical data | Findings regarding the effect of ambient temperature on morbidity and associated health services use, particularly among vulnerable populations such as diabetics, are consistent with previous evidence. |
| FitzGibbon, K.M.37 | USA | * Attendance * Event type * Availability of alcohol or drugs | Mass gathering, medical care should be pre-planned, including venue reconnaissance and an estimation of required resources based on the individual characteristics of the event (weather, attendance, duration, type, crowd mood, alcohol and drug use). Both the Arbon and Hartman models poorly predicted the required resources and could not be successfully validated. |
| Friedman, M.S.19 | USA | * Attendance * Venue * Event type * Mobility * Weather * Availability of alcohol or drugs * Availability of free water * Historical data | Higher medical usage rates have been associated with events of longer duration and extreme weather as well as outdoor events where attendees are exposed to environmental factors. Mobile crowds generally have incurred more injuries than when attendees are seated. Excessive alcohol and drug use has led to increased violence and toxicological effects of polysubstance abuse. However, absolute patient volumes tend to decrease with increasing attendance, and sporting events typically have fewer patients than rock concerts and Papal masses. |
| Goldberg, S.A.16 | USA | * Attendance * Event type * Mobility * Weather * Availability of alcohol or drugs * Precipitation | In data set almost twice as many patients presented for medical attention for intoxication at concerts compared with other event types. Concerts had a significant higher rates of presentation and transport than all other event types. |
| Grant, W.D.27 | USA | * Attendance * Crowd density * Weather * Availability of alcohol or drugs * Allergic reactions | Factors that put fairgoers at risk include, but are not limited to: lack of fluid intake, hot weather, physical exercise and exhaustion, crowd density, and co-morbid illness. |
| Gutman, S.J.38 | Canada | * Crowd density * Venue * Event type * Mobility * Availability of alcohol or drugs | Particular injury and illness patterns prevail depending on the nature of the mass gathering. Rock concert attendees often present with traumatic injuries resulting from crowd motion, thrown objects, or multi-factorial syncope. |
| Guy, A.39 | Canada | * Attendance * Crowd density * Venue * Event type * Weather | Based on observations, the authors suggest that human, environmental, and logistical factors contribute to poor data quality in the setting of mass gatherings. Additional factors that may influence the PPR and workload on event include: changing or extreme weather, surges in patient volume, event type, event location (eg, remote, rural, or urban), event activities that increase risk for illness and/or injury, and crowd demographics and behaviours. |
| Hartman, N.20 | USA | * Attendance * Weather * Availability of alcohol or drugs * Presence of ethanol * Historical data | A classification system that stratifies events, weighted equally, based on weather, number in attendance, presence of alcohol, demographic in attendance, and crowd intentions can effectively predict medical needs at MGs. |
| Hiltunen, T.13 | Finland | * Attendance * Weather * Air quality | The number of patients treated was associated closely with the number of spectators. |
| Ho, W.H.34 | Singapore | * Attendance * Crowd density * Venue * Event type * Mobility * Weather * Availability of alcohol or drugs | This study showed no correlation between attendances and medical presentations. Although prior studies have used heat index to predicted patient presentations, this was not demonstrated in this study. |
| Hsieh, Y.H.40 | Review | * Attendance * Venue * Event type * Mobility | The greatest number of stampedes occurred indoors and in the setting of sporting events (22.8%), followed by religious (19.1%) and political (17.7%) gatherings. The number of participants at an event does affect fatality rates when a human stampede happens. |
| Hutton, A.41 | Australia | * Attendance * Crowd density * Venue * Event type * Mobility * Weather * Availability of alcohol or drugs | The majority of the environmental presentations were alcohol related (32%), heat exhaustion (19%), substance-related (18%), followed by substance- and alcohol-related (16%). |
| Johansson, A.28 | Review | * Crowd density * Mobility * Availability of free water | Human mobility is not random, but is characterised by temporal and spatial correlations. |
| Johnsson, K.M.C.42 | Sweden | * Weather * Mobility * Availability of alcohol or drugs | The character and size of the crowd, nation, and weather significantly influence PPR. It is proposed that if the crowd is seated or moving and whether or not people are participating in the arrangement has been proposed to be considered. |
| Kakamu, T.18 | Review | * Weather * WBGT | MG events should consider WBGT measurements in determining the venues and timing of the events to better avoid heat illness and facilitate maximum athletic performance. |
| Khademipour, G.31 | Iran | * Crowd density | The population flow rate is calculated at the maximum social density point as 2 and the critical density point with maximum social pressure as 8.8 by using the social power model and the formula mi x dvi (t)/dr = fi(t). |
| Krul, J.43 | Netherlands | * Attendance * Weather * Mobility * Availability of alcohol or drugs | Higher temperature and humidity correlate to the number of First Aid attendees at large-scale events. When temperatures are of 30ºC or higher, patient presentations increase. Other influences are the availability of alcohol, and the mobility and activity of the crowd. |
| Locoh-Donou, S.8 | USA | * Attendance * Venue * Event type * Mobility * Weather * Availability of alcohol or drugs * Availability of free water * Historical data * Dew point | Outside (external) or unbounded venues, the absence of free water, no climate control percent (occupied) seating, and increasing heat index are strongly associated with an increased patient census. The presence of alcohol increases patient needs, but not significantly. Collegiate football games have the highest patient census among event categories studied (football, concerts, public exhibitions, and non-football athletic events). |
| Lund, A.30 | Canada | * Attendance * Crowd density * Venue * Event type * Mobility * Weather * Availability of alcohol and other drugs | Minimum data set is defined by the mandatory fields of demographics of event, descriptors of event, descriptors of crowd, risk factors, protective factors, describe any reported deaths that occurred ~3 hours before, or ~6 hours after the event, medical care capability questions and data fields in patient description in the University of British Columbia, Department of Emergency Medicine, Mass Gathering Medicine Registry. |
| Moore, R.17 | Review | * Attendance * Venue * Event type * Mobility * Weather * Availability of alcohol or drugs * Presence of ethanol * Precipitation * Historical data * Cold weather | Aside from weather, event type is the most important predictor of medical usage rates. Confounding factors to this analysis include use alcohol and other drugs, duration of event, crowd mobility, and age of attendees. |
| Nable, J.V.21 | USA | * Attendance * Venue * Event type * Mobility * Availability of alcohol or drugs * Presence of ethanol * Historical data * Weather | The only variable the two models have in common is estimated attendance. The Arbon method requires a specific number of estimated spectators, making the encounter predictions different each day and more accurate than Hartman. Zeitz historical data of recurring events is more accurate than the Arbon predictive model. |
| Perron, A.D.33 | USA | * Attendance * Weather | The heat index was strongly associated with the volume of patients who would be seen at mass gathering event. Linear modelling predicts that for every 10-degree increase in the heat index, three more patients per 10,000 patrons will require care. |
| Selig, B.9 | USA | * Attendance * Weather * Outdoor * Mobility * Precipitation | The regression models indicated that increased temperature was significantly associated with increased total patient presentation rates, but an increase in precipitation significantly decreased presentation rates. |
| Smith, W.P.22 | South Africa | * Attendance * Crowd density * Venue * Event type * Mobility * Availability of alcohol or drugs * Historical data * Weather | The proposed model determines risk profile of an event to suggest medical resources required based off the categories: nature of the event; nature of the venue; seated or unseated; spectator profile; past history of similar events; expected number of spectators; event duration; seasonal considerations; proximity to hospitals; profile of hospitals; additional hazards’ and additional on-site facilities. |
| Steffen, R.14 | Review | * Crowd density * Venue * Event type * Mobility * Weather * Availability of alcohol or drugs * Air quality * Precipitation * Cold weather | Human stampedes and heat related illnesses are the leading causes of mortality during mass gatherings. Characteristics of MGs that may increase the vulnerability of participants include infrastructure, duration, event type, crowd density, mobility, and mood. |
| Tang, N.25 | USA | * Weather * Outdoor * Cold weather | Temperature, in both warm and cold weather conditions, has been shown to have an impact on injury patterns in marathon participants. |
| Westrol, M.S.10 | USA | * Weather * Event type * Availability of alcohol or drugs * Precipitation * Dew point | Heat index and whether the concert was a festival-type of event were associated with increased numbers of patients. |
| Yazawa, K.26 | Japan | * Attendance * Event type * Weather * Availability of alcohol or drugs * Cold weather | Important variables that can affect the levels and types of medical needs include: (1) weather, including maximum daily temperature and humidity; (2) event type and duration; (3) the respective ages of the attendees; (4) crowd mood and density; (5) number of attendees; and (6) alcohol and drug use.">14 Weather greatly influences casualty rates; hot and humid conditions produce high numbers of casualties. |
| Zeitz, K.M.11 | Australia | * Attendance * Venue * Event type * Weather * Mobility * Time of day/week * Historical data | Crowd size, on a daily basis, was readily and accurately predicted using the historical data. Historical data has shown that medical workload is highest on a mid-week day with half-price admission, even though the largest crowds attend at weekends. The Zeitz method also found maximum daily temperature was another significant influence on patient presentations. |

**Table 2.** Environmental Factors which Influence PPR at MGEs

Abbreviations: MGE, mass-gathering event; PPR, patient presentation rate.