Measuring the Masses: Domains Driving Data Collection and Analysis for the Health Outcomes of Mass Gatherings (Paper 3)

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Keywords: case reporting; data modeling; event medicine; mass gathering; mass-gathering health; mass-gathering medicine

Abstract

Introduction: Without a robust evidence base to support recommendations for medical services at mass gatherings (MGs), levels of care will continue to vary and preventable morbidity and mortality will exist. Accordingly, researchers and clinicians publish case reports and case series to capture and explain some of the health interventions, health outcomes, and host community impacts of MGs. Streamlining and standardizing post-event reporting for MG medical services and associated health outcomes could improve inter-event comparability, thereby supporting and promoting growth of the evidence base for this discipline. The present paper is focused on theory building, proposing a set of domains for data that may support increasingly comprehensive, yet lean, reporting on the health outcomes of MGs. This paper is paired with another presenting a proposal for a post-event reporting template.

Methods: The conceptual categories of data presented are based on a textual analysis of 54 published post-event medical case reports and a comparison of the features of published data models for MG health outcomes.

Findings: A comparison of existing data models illustrates that none of the models are explicitly informed by a conceptual lens. Based on an analysis of the literature reviewed, four data domains emerged. These included: (i) the Event Domain, (ii) the Hazard and Risk Domain, (iii) the Capacity Domain, and (iv) the Clinical Domain. These domains mapped to 16 sub-domains.

Discussion: Data modelling for the health outcomes related to MGs is currently in its infancy. The proposed illustration is a set of *operationally relevant* data domains that apply equally to small, medium, and large-sized events. Further development of these domains could move the MG community forward and shift post-event health outcomes reporting in the direction of increasing consistency and comprehensiveness.

Conclusion: Currently, data collection and analysis related to understanding health outcomes arising from MGs is not informed by robust conceptual models. This paper is part of a series of nested papers focused on the future state of post-event medical reporting.

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Introduction

Without a robust evidence base to support recommendations for first aid, health promotion, illness prevention, and medical care at mass gatherings (MGs; hereafter referred to as simply "medical services"), levels of care will continue to vary and preventable morbidity and mortality will continue to exist. Streamlining and standardizing post-event reporting on MG

Abbreviation:
MG: mass gathering

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medical services will improve inter-event comparability and provide the potential for meta-analysis, thereby supporting and promoting the growth of the evidence base of this discipline.

Research on the outcomes of MGs is arguably still in its infancy. Most of the evidence base in this field is in the form of case reports and case series. Although this is an appropriate starting point, growth of the science underpinning the practice of MG medicine (eg, operations, best practices, and team composition) would benefit from the development of conceptual tools to increase the understanding and subsequent integration of MG data. Conceptual tools can provide context for the observation of trends, hypotheses of association and causation, and the collection/dissemination of consistent/cohesive data. Within such tools, data domains serve to organize and prepare data for relational analysis. With comprehensive, relevant, and comparable data, researchers and clinicians will be empowered with the knowledge needed to improve health outcomes associated with MGs.

This paper is part of a series of nested papers focused on the potential future state of post-event medical reporting. The focus of the present paper is on providing a set of evolving, descriptive data domains through which to examine health outcomes for small, medium, and large-sized MGs (ie, excluding mega-events such as the Olympics or the Hajj).

Methods

Analysis of Existing Case Reports

The authors carried out an analysis of post-event case reports drawn from two journals: *Current Sports Medicine Reports* and *Prehospital and Disaster Medicine*. These two journals were chosen as they report on the majority of MG literature. Fifty-four post-event medical case reports were reviewed. Content analysis was used to analyze the data. An inductive, semantic approach was selected, due to the exploratory nature of the study, to ensure that the themes identified were linked to the reviewed literature.[1] This approach allowed for an analysis of data at a semantic level to identify the surface meanings to then cluster data into groups.

The analysis process involved five phases:

1. Familiarizing oneself with the data (through "surface" reading the whole text via line-by-line analysis);
2. Generating initial codes as a means of indexing and categorizing the text to establish a framework of ideas, allowing pattern, value, and evaluation coding techniques to establish frequency, relationship, and underlying meaning leading to the theming of data[2,3] (typical coding labels were words and terms such as "patient presentations," "event character/composition," and "crowd management");
3. Followed by searching for themes as they arose from coding labels;
4. Reviewing themes for accuracy and consistency; and
5. Naming and defining the final themes.

Analysis of Existing Models

Published MG conceptual models were a source of data for this project.[4-12] Data from existing data models for MG health were extracted and entered into an Excel document (Microsoft Corp.; Redmond, Washington USA), seeking points of consensus and difference. This analysis was carried out by four of the authors (ST, EC, HR, and CC).

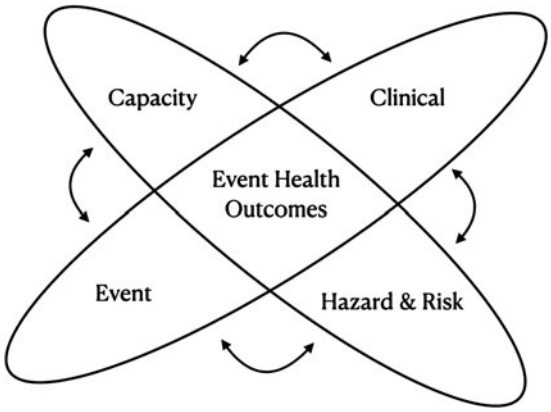

Figure 1. Data Domains for Reporting on Health Outcomes Related to Mass Gatherings.

Results

Case Reports

Analysis of 54 case reports revealed diverse reporting of post-event health outcomes; however, ultimately health outcomes reported (ie, what is observed/measured) were driven by interaction between four, unique domains of data (Figure 1).[13-66] Each of the domains interacted with others to shape health outcomes for a specific event or series of events. Those domains included: (i) Event, (ii) Hazard and Risk, (iii) Capacity, and (iv) Clinical, ultimately mapped out to 16 sub-domains (Table 1).

Event Domain—The Event Domain describes and situates a given MG in time and space, providing enough context for readers to begin to conceptualize the substance of a specific event or series of events through data points describing the event setting, population demographics, scale of the event, anticipated individual behaviors, expected event-related activities, and so on. Subdomains include: event characteristics, event geographics, event climate/weather, and the population demographics. In the examples below, two research teams provide summaries about their respective events, and in those brief descriptions, readers are introduced to the context of the events:

> The event included multiple activities, with a stage for an Olympic gymnastics show, multiple booths for health education, and an area assigned for the ribbon formation (an open stadium). Multiple tents were installed to host the booths. The attendees comprised women 14 years of age or older. Registration was open to the public through a website and online links.[13p.694]

> The tournament involved 10 stadia with, on average, three matches per day during the group match phase, and a round of 16 quarter-finals, semi-finals, a play-off, and the final. Durban's new Moses Mabhida Stadium hosted five games in the group phase, one round of 16 matches, and one of the semi-final encounters . . . The Moses Mabhida Stadium is one of the completely new stadia built specifically for the Soccer World Cup, with a seating capacity of >63,000 people, excluding staff and vendors.[20p.409]

Of note, publications about unique events with broad historical and cultural significance generally provided more detail with regard to event characteristics. In one memorable example, Koçak, et al wrote an "event resume" that provided a snapshot of the cultural importance of the event and highlighted what was different in that iteration of the annual event (eg, attendance levels for the 100th anniversary; international attendance):

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Domain	Functions	Sub-Domain
Event	Provides context	Event Characteristics
		Event Geographics
		Event Climate/Weather
		Population Demographics
Hazard and Risk	Provides information about potential influences on health outcomes	Risk per Event Type
		Risk per Crowd Dynamics
		Risk per Built Environment
		Risk per Timing (eg, surge, multi-day events)
Capacity	Provides information about the available resources and strengths	Event Medical Capacity – On-Site Team Composition and/or Scope of Practice
		Event Medical Capacity – Equipment and Supplies
		Host Community Capacity
		Post-Event Capacity Analysis
Clinical	Contains all sub-domains related to health outcomes	Patient Demographics
		Clinical Demographics
		Acuity Measures
		Impacts on Local Health Infrastructure

Table 1. Conceptual Domains and Sub-Domains

> One hundred years ago, in 1915, the Gallipoli Wars, which extended the First World War because of its results and was known as the "Gentlemen's War," broke out. The battle is also known as "Anzac Day" on the historic stage. Today, the children of the nations involved in this war attend the commemoration ceremonies, which are held annually. This year, on the occasion of the 100th anniversary of the Battle of Gallipoli in Çanakkale, a large number of people from all of the nations who sent troops to the battle were present at the ceremonies. In the commemoration ceremonies, during two days, ceremonies and walks were held in various places.[27p.289]

And Burton, et al explained the historical context of mass fatalities during sporting events. Notably in the quote below, there is a strong interplay between the history of organized sporting events and hazard/risk assessment, which provides an illustration of the integrated nature of the four Data Domains – each influencing the others:

> During the past 40 years, there have been three disasters involving crowds at sporting events in the United Kingdom (UK); all have occurred at British football grounds. Sixty-six fatalities occurred at an event in Ibrox Park in 1971, 40 fatalities occurred at an event at Bradford City in 1985, and most recently, 95 fatalities occurred in the Hillsborough Stadium disaster in 1989. As a result of these tragic events and the subsequent inquiries, substantial changes have been made in the requirements for the provision of safety, including medical coverage at football grounds.[47p.458]

As illustrated above, the Event Domain provides free-form information about a multitude of contextual elements and primes readers to begin thinking about everything from the history of the event (per the specific event; per the event type) and the expected attendees/participants, to the on-site health care resources required to support people to stay well in the context of potential risk behaviors. Data within the Event Domain support and shape planning for the on-site and community-level medical responses. Importantly, the Event Domain should provide enough information for readers to determine if the described event is "similar enough" to their own event to draw conclusions or learnings that may apply to their planning.

The Event Domain answers questions such as: *"What do we already know/understand about this event type in terms of health outcomes?" "What types of illnesses or injuries can we expect to see?" "What climate/weather conditions should we expect given the season?"* and *"Who will be attending this event?"*

Hazard and Risk Domain—The Hazard and Risk Domain contains sub-domains that direct the attention of researchers and clinicians toward analysis of existing/potential hazards and risks with the goal of mitigating the impact to reduce the incidence of negative health outcomes (harms). Sub-domains include: the event type (eg, hot weather marathons); crowd dynamics (eg, rivals versus fans at a football match); the built environment (eg, potential for stage collapse); and event timing (eg, the potential for a substantial surge in patient presentations during a triathlon).

For the purposes of this discussion, "hazards" are things that might cause harm, such as bodies of water, the built environment, motorized vehicles, and so on. In contrast, "risk" is a judgement about the probability that a given hazard will actually result in a harm. And "risk reduction" involves undertaking actions for the purpose of lowering (or eliminating) the probability that a hazard will result in a harm. Authors of this study were unable to discern the existence of a systematic, explicit (as opposed to assumed) approach to the analysis and reporting of actual/potential hazards and risks in most of the literature reviewed.

Hazard and risk analysis, when addressed, was presented either using a category lens (eg, "at music festivals") or an event specific lens (eg, "at this music festival"). The content of a given paper was shaped by the point of view of the author(s). Three main "voices" were manifest in the current body of literature – public health, disaster and emergency management, and medicine:

> Public Health - Anticipated health care concerns included hospital surge (175% in 2004), HIV/STI transmission, imported/communicable diseases, food/water/sanitation-borne illness, interpersonal violence, and health care resource utilization.[36p.149]

> Disaster and Emergency Management - Over 42,000 participants walk a total of 120-200 kilometers (7-12 miles). Alongside, festivities took place,

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> visited by more than 1.5 million people . . . The Radboudumc, a level one trauma center, was situated nearby the start and finish line, and was prepared for the worst. The major concern was accessibility in case of disaster for patients as well as employees, due to self-presenting patients.[56p.130]

> Medicine - The main purpose of this prospective study was to describe the medical problems at the 2013 and 2014 editions of I LOVE TECHNO . . . / Focus was put on the impact of different types of recreational drugs: ethanol, "classical" illegal party drugs, and [new psychoactive substances].[58p.72]

The Hazard and Risk Domain was not widely addressed in the case reports, possibly because the reports are written retrospectively, and hazard/risk assessments are carried out before and during MGs. However, as illustrated below, hazard and risk analysis done prospectively can shape planning for the on-site medical team:

> Following media reports of a death at an [Obstacle Adventure Course] in 2013 when a male participant drowned on an obstacle known as "Walk the Plank" . . . , concerns have been raised about a number of issues related to athlete safety . . . For example, the climate, the terrain, and the unique features of the obstacles may put participants at risk for a variety of illnesses and injuries, including hypothermia, heat-related illness, electric shock, cardiac events, and near drowning. Infectious disease also has been identified as an issue for mud-based [Obstacle Adventure Course], as was the case when norovirus was reported by more than 200 participants and spectators following an OAC in 2013.[30p.183]

Of interest, with the exception of discussion regarding the medical team deployment and the number of on-site ambulances for a particular event, mitigating factors vis a vis a particular event were not typically identified. In the rare example below, AlAssaf, et al identified a factor that reduced the amount of risk for event attendees: "No alcohol or drugs were allowed, as per Saudi rules and regulations, eliminating a major contributor to a high incidence of injuries."[13p.697]

The Hazard and Risk Domain answers the questions: *"What could cause harm (all hazards)?" "What is the probability (risk) that a hazard will cause harm?" "What is the consequence (impact) in the event that a harm does occur?" "What does the on-site medical team need to be prepared to handle?"* and *"To what degree is there a potential risk for the spread of infectious disease?"*

Capacity Domain—The Capacity Domain captures data about both event and host community capacity. Sub-domains include: event medical capacity in relation to on-site team composition, capacity with regard to available equipment and supplies, host community capacity, and post-event capacity analysis. Hardcastle, et al reported on the on-site deployment of medical professionals, as well as patient transportation assets:

> At the vehicle staging area, 10 ambulances, a mass-casualty eight stretcher "disaster bus," a 45-seater "green-code" bus, and two rapid response vehicles (equipped to [Advanced Life Support] ALS status) were held in reserve for any mass-casualty activation. The ambulances and response vehicles (ALS and doctor teams) were deployed within the perimeter before and after matches as early access opportunities for single patient incidents outside the stadium.[20p.412]

Similarly, Ceyhan, et al reported on medical team composition and took a unique approach to describing the size of the medical team by capturing the ratio of medical staff to event attendees:

> The total number of health staff assigned in all meetings was 6,224 with a median 2.4 (1.6-4.1) per 1,000 attendees. The distribution of health staff was as follows: 610 doctors (9.8%) and median 0.25 (0.16-0.41) per 1,000 attendees; 929 paramedics (14.9%) and median 0.40 (0.21-0.61) per 1,000 attendees; 2,066 [emergency medical technicians] EMTs (33.1%) and median 0.65 (0.39-1.33) per 1,000 attendees; 339 nurses (5.4%) and median 0.08 (0.0-0.20) per 1,000 attendees; 366 medical staff (5.8%) and median 1.00 (0.17-0.57) per 1,000 attendees; 763 ambulance drivers (12.0%); and the number logistical support staff was 1,151 (18.4%). The total number of assigned ground ambulances was 763 and median 0.31 (0.17-0.57) per 1,000 attendees, and the total number of health care tents was 150 and median 0.07 (0.03-0.11) per 1,000 attendees.[63p.4]

In terms of external capacity, or the capacity of the host community, Munn, et al gave a succinct description of the capacity of the host community, providing information vital for context in planning on-site health services:

> The farm was located in a rural setting with the nearest town of 1,139 inhabitants located 11 kilometers (seven miles) away. Local provincial ambulance was based in town and had a response time of approximately 20 minutes. The local referral hospital, located 52 kilometers (33 miles) from the event site, was approximately 60 minutes away by dirt road egress and provincial highway.[38p.226]

The main features of the Capacity Domain are the capture of data related to medical team composition, physical deployment of the on-site medical team, transport (on-site) and transfer (off-site) capability, and more rarely, data about equipment and supplies available on-site. Of note, two things were missing from the capacity discussion. First, there were very little data provided related to scope of practice and medical direction. And second, despite the importance of understanding the degree to which the human and physical resources deployed matched the actual need, such an analysis was generally absent from the 54 case reports reviewed.

The Capacity Domain begins to answer the questions: *"What kinds of health challenges can be managed on-site?" "How might one mitigate the impact of a given event on local health care infrastructure?"* and *"How closely did the deployed resources match the actual need?"*

Clinical Domain—The Clinical Domain is used to describe the patient presentations and to provide the reader with an in-depth understanding as to what occurred medically at a given event. Sub-domains include: patient demographics, clinical demographics, acuity measures, and impact on local health infrastructure, as measured by ambulance transports (commonly reported) and patient self-presentations to off-site health resources (uncommonly reported). In the reports reviewed, MG researchers usually reported on the type of patient presentations, whether classified according to body systems (eg, dermatologic, cardiac) or presenting complaint (eg, headache, ankle injury). For example, Krul, et al provided a detailed description of patient presentations below:

> Among all presenting patients, 5.7% were found with altered nutrition (less than recommended body requirements), 3.6% with sleep pattern disturbance, and 2.1% with fluid volume deficit. More than a quarter of all evaluated cases (27.4%) were recreational drug-related, involving substances used alone or in combination . . . A total of 1.5% of the party visitors suffered from asthma or diabetes and accessed the [first aid services] (primarily for forgotten medication).[29p.73]

And Luther, et al captured local impacts on health services providing detailed information about transfers to acute care. Of note, measures of positive (ie, mitigating) effects of on-site medical teams were captured only indirectly through reporting number of patients seen and treated by the on-site medical team:

> The ambulance service transported five patients to hospital following initial assessment by the on-site first aid service. These patients included: seizure, dislocated shoulder, alcohol intoxication, drug intoxication, and a head

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> injury with loss of consciousness and altered responses. All other presentations were managed on site, either being returned to the event or recommended to go home.[32p.222]

Munn, et al provided a detailed summary about a subset of patients who presented at a large-scale music festival:

> Three event years were reviewed with 328 of 4,032 unique medical presentations deemed to have had altered content or consciousness. Of the altered content subset, 22 required physical or chemical restraint. Of the 255 altered consciousness presentations, 144 were transient syncope-like cases, 37 were seizure-like cases, and 41 had [Glasgow Coma Score] GCS ≤8 documented at some point during the visit. There were no endotracheal intubations or deaths. Seventy percent of altered patients stayed less than 30 minutes.[39p.132]

Of note, there is a signal that researchers are turning their attention to both understanding *and* explaining health outcomes. For example, Anikeeva:

> The highest number of patient presentations per event was observed at mass gatherings where the mean temperature was between 20°C and 25°C. Somewhat surprisingly, events with the highest average temperature of over 25°C had the lowest number of patient presentations per event, which is at odds with previous findings that have demonstrated a positive correlation between high temperatures and heat-related illness presentations. This may be explained by the tendency for attendees to take extra precautions . . . [when] reminded to do so by environmental cues and health promotion initiatives at events.[14p.374]

The Clinical Domain answers the questions: *"What happened for the people who attended and/or participated in the event and presented with health-related concerns?"* and *"What degree of burden was placed on existing health infrastructure?"*

Existing Conceptual Models for Mass Gatherings

In addition to published event reports, the authors reviewed existing, published data models for MGs. A brief description of focus, as well as points of alignment and divergence, are captured below.

Little theoretical work vis a vis data and reporting currently exists in the MG health literature. However, a few researchers have published on event modeling and population modeling for events, focusing on data points that describe MGs and the populations affected.[8,11,12] In addition to this work, Schwellnus, et al used a consensus process and proposed 36 essential data points for endurance sporting events, along with 27 "additional" data points.[8] The essential data points they suggested were grouped into themes or categories in which like data are grouped with like. The strengths of this approach are the degree to which a data set that is tailored to a specific event context can contain both generic and specific data points. Meaning, generalizability is sacrificed, to some extent, for specificity.

Arbon, et al proposed a model for data collection at MGs that included biomedical, environmental, and psychosocial domains.[4] Other researchers subsequently built on Arbon, et al's work and wrote three papers describing, in some detail, the variables that might fit into the patient, environment, and psychosocial domains.[5,67,68] The strength of the Arbon model is a focus on data modelling specifically for MGs. In addition, the Arbon model (and subsequent work by Hutton, et al) provides a pathway for thinking beyond the most common *clinical* variables.

Discussion

Theory development to support the science of MG medicine is in its infancy. Theory not only informs and guides practice, but also has the potential to create discussion and debate in the MG community, further contributing to the evolution of the theory base. The data domains proposed above inform researchers about what they might usefully pay attention to in relation to focused, lean categories of data collection. This paper attempts to answer the question: *Broadly, what types/categories of data should be collected?* The companion paper answers the questions: *How do the types/categories of data interact to shape health outcomes? How do various data domains relate to and influence one another?* and *What data points are independent, and which influence dependent variables?* Ideally, conceptual and operational lenses support the real-time delivery of health care services during MGs.

Standardizing the Collection of Essential Data Points

Alignment between clinicians, researchers, and event production teams around what constitutes "must have" data will move the event community in the direction of standardized, consistent data collection. Improving the understanding of health outcomes requires the standardization of post-event medical reporting.[33] Case reports and case series have a recognized role to play in sharing and advancing knowledge and many health care specialties have recommended specific standards for reporting as an important strategy for improving data collection.[69-74] In the context of MGs, standardized reporting has been discussed for years, with several authors having argued that this strategy will improve the quality of case reports.[4,8,75-77] Setting minimum standards for case reporting is recognized as an important strategy for improving data quality.

Shifting from Description to Explanation

The proposed data domains may advance the theory underpinning MG medicine. In turn, theory helps researchers evaluate outcomes.[78] The development and evolution of data domains to support the collection of essential data points has the potential to shift the conversation from pure description to providing enough (consistent) data to create a more comprehensive picture including not only *what* happened in relation to health outcomes, but also *why* it happened. Maintaining a tight focus on clinical outcomes, and adding a bigger picture view through the inclusion of data addressing internal/external capacity as well as the hazard and risk profile of a given event, has the potential to shift post-event reporting away from pure description, toward hypothesis generation and prospective studies that might explain cause and effect.

Within the present project, there is a signal that the proposed data domains are to a great extent integrated and interactive. For example, an upstream risk assessment (Hazard and Risk Domain) for a music festival (Event Domain) might identify that attendees will possibly choose to imbibe recreational drugs. This would result in measures being taken to increase the capacity of the team to care for intoxicated patients (Capacity Domain). That action would ultimately have the downstream effect of reducing the number of transfers to hospital as many intoxicated patients could be safely cared for on-site (Clinical Domain).

Data Domains Inform Planning and Delivery of Care

The data domains proposed as drivers for future post-event case reporting are meant to be employed *both* prospectively *and* retrospectively. That is, the data domains can be applied to a given event as part of the planning process and as part of after-action case reports. As Woodall, et al pointed out, there is currently little evidence to provide guidance for clinicians about the appropriate composition and deployment of medical teams, and so decisions are made based on historical knowledge and local expert opinion rather than on best available evidence.[60] Information generated in each of

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the proposed data domains could inform planning with regard to medical teams. In addition, data domains support MG medicine clinicians to consider how hazards and risks, once identified, may be mitigated or even eliminated.[31,79] As Ho, et al stated, the goal of an on-site medical response is to ensure timely access to appropriate health care resources:

> . . . preparation for mass gatherings includes risk assessment and planning coupled with system enhancements that ensure sufficient capacity and capability for the provision of medical care to attendees, without adversely affecting baseline medical care in the host community.[21p.489]

In summary, the authors are seeking to shift the focus from what *is* done, to what *ought to be* done vis a vis reporting post-event health outcomes. The proposed interdependent data domains provide a road map for clinicians and researchers, suggesting essential data points that should be captured when reporting health outcomes post-event. To the authors' knowledge, no research team has attempted a content analysis of post-event medical case reports. This method allowed the authors to develop a set of data domains that have the potential to inform the future state of post-event medical case reporting.

Future Directions

Based on the data domains derived, the development of a conceptual model of data relationships has occurred in parallel and accompanies this paper.

Limitations

The data domains presented in this paper are based on a qualitative analysis of ten years of event reports drawn from two journals and integration of pre-existing literature on event data modeling. It is possible that with a broader literature search, going back more decades and/or a literature search that included additional journals, would yield additional results.

Conclusion

The set of data domains (descriptive) developed for the present study has the potential to expand the types of data collected with regard to MGs. The Event, Hazard and Risk, Capacity, and Clinical Domains have the potential to focus the attention of researchers, supporting them to provide lean, yet comprehensive analyses regarding the health outcomes of MGs.

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