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EDITED BY

Andrew Milsten,
University of Massachusetts System,
United States

REVIEWED BY

Tamorish Kole,
University of South Wales, United Kingdom
Jan-Cedric Hansen,
Centre d'Hébergement et
d'Accompagnement Gériatologique
(CHAG), France

*CORRESPONDENCE

Marc-Antoine Pigeon
✉ marc-antoine.pigeon.med@ssss.gouv.qc.ca

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Mass gathering healthcare and safety: current knowledge and future directions

Marc-Antoine Pigeon^{1,2*}, Anne-Julie Demers¹ and
Gregory Ciotton^{2,3}

¹Département de médecine de famille et médecine d'urgence, Faculté de médecine, Université de Sherbrooke, Sherbrooke, QC, Canada, ²CRIMEDIM—Center for Research and Training in Disaster Medicine, Università del Piemonte Orientale, Novara, Italy, ³BIDMC Disaster Medicine Fellowship, Boston, MA, United States

Introduction: Mass gathering medicine (MGM) has been a rapidly evolving area of expertise for many years, with pearls and pitfalls emerging from recent literature. Gaps have been identified: lack of a pragmatic definition of MGM, weaknesses in data sets used to report on major events, difficulties with developing tools to help organizers assess health and safety issues. This study aims to map and describe the current body of literature on mass gatherings in order to identify strengths and weaknesses in the healthcare response, guiding future research in the field.

Methods: This study is a bibliometric review. Using the broad research terms “mass gatherings” and “major planned events”, Pubmed, Web of Science and Google Scholar were searched for publications up to Sept. 13, 2024. No restrictions of language or type of articles were used. All gray literature was included. After removal of duplicates, two independent reviewers confirmed relevance, and articles were organized according to date of publication, type of event (7), main subjects categories (11). Further keywords analyses have been conducted using VOSViewer (v.1.6.20).

Results: Initial database searches yielded 4,526 results. After the removal of duplicates and non-related articles, 898 publications remained and have been categorized, dating from 1978 to 2024. Full text analysis was possible for a total of 854 articles. More than 25% of the articles concerned religious events, while categories like infectious diseases and public health were the main subject of more than one third of the papers. Music events, spontaneous gatherings and environmental/remote events were underrepresented. Main topics like heat-related illnesses and environmental health, training and psychosocial aspects were also underrepresented. Keywords analysis allowed for the identification of areas of scarce knowledge that need further development.

Conclusion: Mass gathering health and safety literature has grown rapidly over the past years. This study identified areas of strong knowledge to build upon, while more scarce areas like psychosocial aspects, quality evaluation, management and supervision, training and development of formal expertise are still in need of improvement.

KEYWORDS

mass gathering, mass gathering medicine, major planned event, medical response, review, bibliometric, research

Introduction

Mass Gathering Medicine (MGM) is best described as a niche area of expertise within the broader world of medicine (1). It encompasses elements of medical care, crowd management, public health, psychology, infection control, counter-terrorism medicine, weather-related illness (2). These areas, though interdependent to MGM, were developed at various paces and influenced by important events, including the COVID-19 pandemic. To date, most of the medical literature on mass gatherings focuses on one or two of these specific areas of expertise, with very few papers focusing on the development of conceptual models and the interconnection between these different areas (1, 3). Furthermore, the general slowing of mass gathering activities worldwide during the COVID-19 pandemic seems to have been a catalyst to the increased number of research publications in the field, as well as the heterogeneity of topics.

Over the past 25 years, guidance for research has been suggested (4–6). Some authors even suggested the research community adopts a standardized way to report data and share knowledge, which could help deal with the important heterogeneity in the advancement of the different domains, as previously described (7, 8). A general call to action toward more research in MGM was put forth in 2012 (9) and reiterated, in 2024, that recommended collaboration between various stakeholders and subject matter experts (10). In that context, it has become difficult to keep track of all literature published, and to correctly identify gaps in collective knowledge. This paper aims to understand connections between already published work and map the current literature, in order to guide future research efforts.

Methods

Study design

Pubmed, Web of Science, and Google Scholars were searched with the broad keywords “mass gatherings” and “major planned events”. No restrictions of field, language or date of publication were considered. All types of publications were considered, including case reports, posters, abstracts from conference presentations and gray literature. After the removal of non-related articles and duplicates, articles were classified in categories according to their main focus and into groups according to the type of event they refer to. For articles covering more than one topic or not addressing a specific type of event, a category labeled “mass gatherings in general” was created.

Bibliometric analyses identify knowledge gaps in a field and serve to guide further research (11). As the literature on mass gathering medicine includes a number of articles that are too large and unfocused for systematic review, as well as too heterogeneous to allow meta-analyses to be conducted, bibliometric principles are appropriate for the purpose of this study. The principal objective is science mapping; therefore, keywords analysis was conducted. Because keywords are used by authors to identify the most important topics covered by their article, they provide useful information to describe the state of available knowledge and are a reliable description of the content of papers (11, 12).

Ethical considerations

As this study only involves a review of existing publications and does not involve any human or animal subjects or datasets, no ethical approval was obtained.

Data collection

Data extraction was conducted in September 2024. A total of 4,526 articles were obtained, and after removal of duplicates, the total was reduced to 2,590. Title and abstract revision were then conducted in order to remove the articles that were not related to the study topic. A total of 904 articles remained and this number was reduced to 895 articles because the full text for 9 articles was not able to be retrieved. Keywords analysis was conducted on a total of 854 articles because 41 of the full texts retrieved did not mention any keywords (e.g., Conference abstracts, books, etc.).

Data analysis

The first part of the analysis, which consisted of a screening of all references to regroup them in categories and then by type of events, was conducted using the statistics in Microsoft Excel software. Two reviewers conducted this analysis independently and disagreements were sorted out by consensus discussion. Keyword analysis was conducted on the 854 full texts available using VOS Viewer version 1.6.20.

Results

Based on well-known domains related to mass gathering healthcare and safety (3, 13), categories encompassing all greater themes were created.

The number of articles per category are presented in Table 1. The largest number of articles fall under the Public Health and Security category, with a total of 185. The second largest was Epidemiology/Infectious diseases, with a total of 166. The Respiratory disease category, which is closely related to the previous two, includes 93 articles. Altogether, these three categories represent more than 52% of the literature that was analyzed in this study. At the other end of the spectrum, categories Intoxication (drugs/alcohol), Heat-related Illness and Environmental Health Risk/Injuries accounted for a combined 3.16% of the articles. One hundred and thirty three articles (15.5%), focused on preparation and prevention for health and safety aspects, including articles on tools specifically designed to better assess an event's specific needs in terms of resources.

Table 2 presents the number of articles by type of event. Mass Gatherings in General is the largest group of articles with 308 (36%) articles. It is also the broadest in scope, as it includes any article that does not specifically refer to one type of event, or that includes more than one type. Religious Events is the second largest group, with 270 articles (32%), followed by Sport Events, containing 170 articles (20%). Combined, these three groups account for 87% of the papers. The other categories contain far fewer articles; with 3

TABLE 1 Description of categories and number of articles.

Category	Description	# Articles	%
Respiratory diseases	Related to air-borne transmission or respiratory infections (COVID-19, Influenza, etc.)	93	10.89
Epidemiology/infectious diseases	Related to infectious diseases, study of transmission (not specifically respiratory)	166	19.44
Public health/security	Related to disease surveillance, syndromic recognition, public health measures (masks, etc.), vaccines and prevention/awareness for general public	185	21.66
Trauma/injuries	Related to description of injury and disease patterns, patient presentations, MCI management, etc.	57	6.67
Preparation/prevention	Related to risk assessment or planning tools aiming at prevention or allocation of resources from an event planner or stakeholder's perspective	133	15.57
Heat-related illness	Related to the effects of heat on participants	9	1.05
Medical care/services	Related to the medical care and services offered during mass gatherings	113	13.23
Training/teaching/research	Related to simulations, training, trends in research or description of teaching programs and their effects	56	6.56
Intoxication (drugs or alcohol)	Related to alcohol and drugs consumption and/or syndromes during events	7	0.82
Psychosocial and mental health	Related to the mental health of participants and healthcare workers	24	2.81
Environmental health risk/injuries	Related to effects of environment (dryness, cold, weather, etc.) and effects on people and crowds	11	1.29

TABLE 2 Description of types of events and number of articles.

Type of events	Description	# Articles	%
Environmental/wilderness	Remote locations and/or events specifically involving a context of wilderness medicine	3	0.35
Sports	All types of events specifically dedicated to sports, including Marathons, sport competitions, Olympics, etc.	170	19.95
Religious	All types events oriented toward religion or Faith, including pilgrimages	270	31.69
Riots, protests or terrorism	Political protests or pacific assemblies, including spontaneous gatherings related to militancy. Includes studies related to the sabotage or attacks targeting mass gatherings	10	1.17
Cultural	Social gatherings oriented toward culture, not otherwise included in other categories (ex: Scouts assembly, book fair, schoolies, etc.)	55	6.46
Music	Music festivals or celebrations	36	4.23
Mass gatherings in general	Studies involving many types of events or not specifying a type of event in particular	308	36.15

related to Wilderness/Remote Area Events, while 10 are related to Riots, Political Protests or Violent Sabotage/Terrorism combined.

Figure 1 presents the number of articles published per year. The oldest paper retrieved dates from 1978. Up until 2010, 10 or less papers were published per year. As the graph shows, there has been a steady increase in the number of publications from 2010 to 2022, when more than 100 papers related to major planned events or mass gatherings were published.

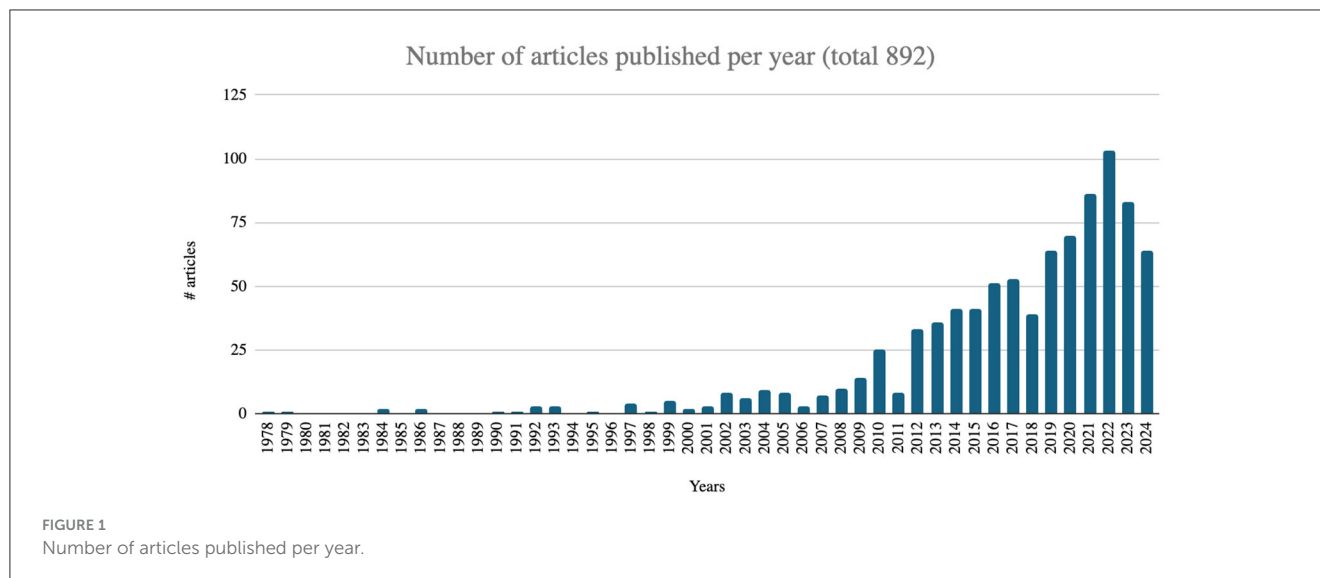
Table 3 presents the most prevalent keywords per category/type of events. The keywords “humans”, “mass gatherings” and “male/female”, that were highly prevalent in all groups, were deemed trivial to further analysis and have therefore been removed. Some keywords were present a significant number of times among all categories: “Hajj”, “Saudi Arabia”, “COVID-19/SARS-CoV-2”, and “mass behavior/crowding”. Concepts of “risk assessment”, “disaster planning”, “public health” and “syndromic surveillance” also were consistently present, but in less prominent numbers. These last keywords were also present in a less uniform way across the groups of articles.

Table 4 presents the least prevalent keywords per category/type of events. Results are more heterogeneous, and the less prevalent keywords are rarely present in more than one group. Nonetheless, “Arbaeen” and “Kumbh Mela” as well as “mass casualty incident” were repeated. In some groups, the less prevalent keywords were some of the most prevalent in other groups, for instance “emergency preparedness”, “risk management” and “syndromic surveillance”.

Discussion

High prevalence of some keywords and article categories:

An abundance of studies covers religious events as well as infectious diseases. Keywords analysis of these groups also shows that it seems to be a consistent phenomenon across the literature. While the Hajj is a very redundant research topic throughout all the analyses conducted, it also appears that it is a platform that is used quite often to study infectious diseases and public health



in general. Keywords like “Islam” and “Saudi Arabia”, while not specifically referring to the Hajj, point in that direction as well, as it is an easy inference to make that these articles also refer to that recurrent pilgrimage. Infectious diseases appear to be a very important subject in the mass gathering literature, as many articles on the matter were found. Since they have the potential to disrupt the health resources of a mass gathering, and on a wider scale, to create epidemics for both host and home countries (depending on the incubation period of the disease), it appears logical that they are a widely studied topic. This being said, the keywords analysis demonstrates that, while there are a lot of articles published already, some important events like the Olympics, Kumbh Mela or Arbaeen appear to be much less studied. This same phenomenon is observed for other infectious diseases outside of COVID, such as influenza, measles, meningitis, or food-borne infections as well as zoonoses, all of which are a great risk for locals and travelers attending a mass gathering (14). This may be explained by the fact that testing to diagnose these diseases may not be as readily available as testing for COVID. Another explanation may be that it was previously shown that these diseases have a much lower penetrance rate (15), or because there are many mitigation strategies already available (16).

“COVID-19” and “SARS-CoV-2” are also very prevalent keywords throughout many groups of articles analyzed, and this phenomenon is not limited to the infectious diseases and respiratory diseases groups, although they show the greatest prevalence. This finding is easily explainable by the COVID-19 pandemic that caused great turbulence in countries worldwide, as well as paralyzed the organization of most mass gatherings around the world. The years with the highest numbers of articles published also coincide with the pandemic.

“Crowding” and “Mass Behavior” are a third theme that is consistently present as a keyword throughout all groups of articles. Whereas, crowding predisposes to the spread of infectious diseases and other respiratory diseases, it can also pose challenges from a public health perspective. Event planners have to consider crowding when planning for ingress and egress routes to their events. They must also plan for hygiene facilities, potable water,

food and, in some cases, accommodation for the masses of people that will participate in the event. Finally, crowd flow also poses a challenge as it can predispose to stampedes and crowd crushes (17). Sadly, there were not enough articles in the psychosocial/mental health category to run a proper keyword analysis. This being said, a brief review of the articles in this category demonstrates that some articles discuss psychology and behavior of crowds, alcohol and drug consumption and some other psychosocial aspects like sexual assaults or fire jumping (18). Further research on behavioral health and psychology of crowds is necessary to better understand this multifaceted aspect of mass gatherings (10).

Low prevalence of some keywords and article categories:

Very few publications related to “Environmental/Wilderness events” were captured by the research strategy used. Although extreme sports and events related to dangerous environments are gaining in popularity and pose important challenges for medical planning (19), their relative absence in the results may simply be explained by the fact that they are not inherently mass gatherings. This being said, they still share important pitfalls with mass gatherings in terms of the different domains involved in health and safety planning, the important resources they may necessitate (20), as well as the straining effect they can have on hospitals and medical resources of their host community. “Heat-related illnesses” is another category that contains few papers. Keyword analysis of the bigger categories also revealed that heat was not listed by authors as a predominant theme in their articles. Of note, out of nine articles in the “heat-related illnesses” category, seven dated from 2021 onwards, which may be a sign of a growing interest in this specific field related to mass gatherings. This emergence of trend would also be aligned with climate change and global warming, and the significant risk they pose to people living in or traveling to hot-climate regions (21) as would be aligned with the World Health Organization (WHO) recommendations on heat-health action plans (22).

“Riots/Protests/Terrorism” is another category where the literature is scarce. Only 11 articles were obtained by the research strategy used, one of which could not be retrieved for full-text

TABLE 3 Keywords of high occurrence in categories/groups with 50 or more articles.

Keyword	Respiratory diseases	Epidemiology/ infectious	Public health/ security	Trauma/ injuries	Preparation/ prevention	Medical care/ services	Training/ teaching research	Sports	Religious	Mass gatherings in general
Haji	15	46	22	6	7	7	–	–	94	–
Saudi Arabia	12	52	11	–	12	–	–	–	63	–
Islam	10	21	–	5	–	–	–	–	54	–
COVID-19/SARS-CoV-2	67	25	12	–	8	–	–	13	–	31
Public health	7	9	6	–	–	–	–	–	–	17
Syndromic surveillance	–	–	9	–	–	–	–	–	–	–
Disease outbreak		11								
Risk assessment	–	–	–	–	13	–	–	15	–	13
Risk factors		7								
Disaster planning	–	–	–	–	10	–	3	–	–	–
Health planning							3			
Mass behavior	–	–	–	6	6	5	16	–	–	40
Crowding	12	36	16	6	–	8	12	12	30	34
Mass casualty incident					6					
Travel	10	26							46	
Emergency medical services					7	10				20
Sports		6								
Other	–	Animals (8); Global health (8)	Influenza (5)	Patient presentation rate (5)	–	Middle-age/young adult (31); Child (10); Infant (5)	Patient presentation rate (2); Models/theoretical (4)	Middle-age/adolescent (12); Soccer (16); Qatar (9)	Young adult (23); Middle-age/adult (47)	Adolescent/young adult (28)

TABLE 4 Keywords of relative low occurrence in categories/groups of 50 articles or more.

Respiratory diseases	Epidemiology/ infectious	Public health/security	Trauma/ injuries	Preparation/ prevention	Medical care/ services	Training/ teaching/ research	Sports	Religious	Mass gatherings in general
Influenza (3)	Arbaeen (2)	Kumbh Melah (2)	Risk management (2)	Data collection/ modeling (4)	Severity of illness Index (2)	Emergency preparedness (2)	Disaster planning (5)	Arbaeen (5)	Health planning (5)
Quarantine (3)	Flavivirus (2)	Grand magal (2)	Workforce (2)	Kumbh Mela (3)	Quality of Healthcare (3)	Population density (2)	Mass Casualty Incident (5)	Kumbh Mela (9)	Risk management (5)
Contact tracing (3)	Monkeypox (2)	Cholera (2)	Mass casualty incident (2)	Triage (2)	Workforce (4)	Curriculum (2)	Public Health Surveillance (5)	India (14)	Emergency preparedness (5)
Mass screening (3)	Meningitis (2)	Food poisoning (2)	Medication (2)	Workforce (2)	Mass casualty incident (3)		Emergency medicine (5)	Pilgrimage (13)	Syndromic surveillance (5)
Olympics (3)	Measles (2)	Biosurveillance/ methods (2)		Nurse's role (2)	Drug stability (2)		Prospective studies (5)	Child (6)	First aid (5)
	Yellow Fever (2)	Vaccination (2)		Jeddah Tool (2)				Vaccine (9)	Social identity (6)
	Foodborne disease (2)	Concerts (2)		Models/ organizational (2)					
	Syndromic surveillance (2)	Carbon dioxide (2)		Algorithms (2)					
	Camelus (2)	Water microbiology/ wastewater (2/4)		Patient presentation rate (2)					
		Antibiotics (2)		Social norms/ social identity (2)					
		Preventive measures (2)							

analysis. Keywords analysis also did not find the presence of keywords specifically related to this topic. However, as shown in [Tables 3, 4](#), the keywords “disaster planning”, “risk assessment” and “mass-casualty incident” appeared a few times and share resemblance in context. Political tensions and the rise of extremist movements create a unique context in which spontaneous gatherings are prone to happen ([23](#)). Likewise, mass gatherings create a unique target for violent sabotage and terrorism ([24](#)). With the recent creation and development of counter-terrorism medicine as a specific area of expertise in disaster medicine ([25](#)), hopefully, this important topic related to mass gatherings will continue to develop.

As previously mentioned, even though “disease outbreaks” and “syndromic surveillance” appear quite a few times in the keywords analysis, very few publications specifically mention infectious diseases that are not COVID-19. In fact, [TABLE 4](#) shows the low prevalence of the keywords “Influenza”, “monkeypox”, “meningitis”, “measles”, “food poisoning/foodborne disease”, “water microbiology/wastewater”, or “antibiotics”. Although it is easy to understand why COVID-19 is very prevalent in the keywords analysis, the very low prevalence of the other keywords is somewhat concerning as they are not analyzed in proportion, but in absolute numbers. Since nearly one in ten people worldwide fall ill to foodborne illnesses each year ([26](#)), this example alone makes for a strong recommendation to develop more research on these topics. This being said, important logistical barriers, not readily available testing for all these infectious diseases, and under-developed mechanisms of declaration of symptoms in large events in developing countries are all significant burdens that will need to be overcome to allow for knowledge expansion on these aspects of MGM.

As shown in [Table 1](#), only 7 articles were specifically related to intoxications by drugs or alcohols during mass gatherings, representing only 0.82% of all the articles retrieved by the research strategy used. Keywords analysis further demonstrated that seldom did keywords related to drugs or alcohol consumption, testing, or harm reduction programs appear in the analysis. Perhaps these aspects are more difficult to study because the legal framework is different between countries, so gathering data on illegal substances in an unbiased way during mass gatherings can be difficult. These aspects of mass gatherings may also be considered as bad publicity by event planners and, therefore, they may not authorize data collection or study of their events.

Because the presence of medical services at mass gathering events tends to reassure attendees, who then modify their behavior accordingly ([27](#)), perhaps harm reduction programs and other social initiatives could be an interesting way to study this complex phenomenon during mass gatherings. A more thorough systematic review of articles mentioning “Public Health” as a keyword may also reveal some of these previously reported aspects, but a more detailed analysis was beyond the scope of this article.

Keywords that are less present or absent but may be avenues for further research.

Throughout the keywords analysis some themes were rarely present but should be highlighted more specifically.

Artificial intelligence

Artificial Intelligence is a rapidly evolving area of interest for many aspects of everyday life. Medical services, security services, law enforcement and many other agencies or stakeholders involved in the planning and delivery of a major planned event will, if they have not already, encounter artificial intelligence applications of utility in their field. While use of artificial intelligence in crowd surveillance strategies ([28](#)), for mass gatherings is already being used ([29](#)), more research and knowledge sharing is needed on this emergent but game-changing technology, both in terms of potential uses for good and for malicious intentions. On the clinical side of things, artificial intelligence is currently studied for many purposes like triage, EKG interpretation, radiology, filing and notes, etc. Many of these purposes could be of interest for mass gathering medical care and should therefore be studied.

Terrorism, intentional harm and hybrid/unplanned gatherings

The number of acts of terrorism and violence targeting festivals and music concerts is on the rise worldwide and are causing thousands of fatalities and injuries ([24](#)). Political tensions and battles are also very prevalent and represent a significant burden for law enforcement and prehospital providers ([23](#)). Moreover, terrorism and other acts of sabotage often lead to mass casualty incidents, exposing medical services to a significant burden of work, as well as various unusual contexts in which they are not accustomed to, such as chemical/biological/radiological/nuclear/explosive (CBRNE) events, unsafe environments, and asymmetric attack. Of note, our research strategy found no paper specifically interested in CBRNE and mass gatherings, and our keyword analysis did not find CBRNE to be one of the main topics in any category or group of articles. Although it is highly probable this is due to our research strategy not aiming directly at this theme, it still highlights the paucity of literature on these threats to public safety.

The search strategy used, as shown in [Table 1](#), obtained a very limited number of articles for the Riots, Protests or Terrorism category. Perhaps this is caused by the authors not considering political manifestations or spontaneous assembly of people to be mass gatherings, though it can be argued they have a lot in common with other types of major planned events. Collecting valid and reliable data on such unplanned events can also be challenging, and therefore account for the limited number of articles. Since political tensions and protests of all kinds may affect major planned events or even be mass gatherings themselves, more research should be done on the topic, and awareness on preventative measures, ways to organize medical care and security services around political gatherings, as well as health and safety planning for unplanned mass gatherings are all elements for which there should be more training and research. Training law enforcement and medical providers on ways to respond to such events should also be considered as a priority ([30](#)).

Quality assessment/improvement

Keywords regarding quality only appear in one small section of the analysis, as shown in [Table 4](#). Over the past 30 years, a significant portion of the literature published on mass gatherings has been in the form of case reports and is very heterogeneous ([31](#)). Many factors may contribute to this great heterogeneity, which could be both in terms of data reporting and medical care in itself, but also in the lack of proper quality assessment. As it has been acknowledged in the literature, mass gathering experts and healthcare providers need a uniform way to report and compile data related to their event ([7](#), [8](#), [13](#), [32](#)). Developing a framework to conduct proper quality assessment and identify areas for improvement via a consistent and reproducible process, could pave the way to a more homogeneous set of standards that could be adapted to local particularities. Perhaps the recent publication of the WHO Mass Gatherings All Hazards Risk Tool ([33](#)) will be the starting ground of a more standardized way to assess health and safety needs for mass gatherings, therefore setting the basis of further quality assessments.

Management/supervision/laws/regulations

As mass gatherings are becoming common place in most major cities worldwide, institutions and governments should develop regulations and legislation to guide event planners toward health-related practices to ensure the wellbeing and safety of attendees. Two studies published nearly 25 years apart demonstrate that legislation on mass gathering medical care and safety planning is scarce, at least in North America ([34](#), [35](#)). Though guidelines exist, they may not be enforceable and, therefore, event planners are free to plan according to their own agenda. Perhaps this absence of formal guidance and legal framework is attributable to the lack of evaluation and quality assessment of the practices in place nowadays, therefore prohibiting lawmakers and politicians from establishing standards based on good quality data and evidence of the efficacy of the procedures they would consider enforcing. More regulation is needed, and a more formal guidance should be established, therefore ensuring health and safety issues of mass gatherings are addressed properly.

Psychosocial

This study identified only 24 articles (2.8%) in the Psychosocial/Mental Health category. Keyword analysis also showed that mental health related terms are rarely present. A more detailed analysis of the articles in this category also proved that mental health is covered from two main perspectives: that of the participants, and that of the healthcare providers. Although these two aspects are of equal importance, more thorough research focusing on mental health and all other psychosocial aspects of mass gatherings in general should be done.

Limitations

The limitations of this study are related to the research method, the software used, and the lack of qualitative analysis combined with the quantitative analysis done.

First, despite having used three different databases and incorporating gray literature to broaden the results, no iterative research method was done. Thus, it is possible that relevant studies were missed. To further optimize the number of articles obtained, no language restriction, date restriction or type or articles restriction was used.

Second, the software used to analyze the data was VOSViewer. The authors were using this technological tool for the first time. Consequently, they did not have a full understanding of the software's every function and were learning as they went. This could have led to biased results, as the authors were not aware of the software's every limitation. Furthermore, time trending analysis could have been conducted, therefore showing the development of knowledge in relation to time and events. These complex analyses could have better refined the authors' understanding of keywords, but this level of detail was beyond the scope of this paper.

Third, bibliometric studies are inherently quantitative. However, mass gathering medicine also carries an important qualitative dimension. While this study has provided a quantitative analysis on the research literature in mass gathering medicine, it has not addressed its qualitative dimension. One way to overcome this limitation would be to conduct a mixed-method research approach, including both quantitative and qualitative analyses, such as adding interviews with experts on the topic to complement the quantitative results with descriptions and explanations on mass gathering medicine, better orient the keywords analysis, and formulate more perspectives for future research.

Conclusion

Our strategy allowed us to organize and map the current knowledge on mass gathering health and safety aspects. Religious gatherings like the Hajj, infectious diseases and public health, as well as crowd psychology and mass behaviors figure among the topics on which broad literature is available. The keyword analysis allowed for identification of areas where there is a paucity of literature and, therefore, we must advocate for further development in these areas, hopefully correcting geographical imbalance in research and strengthening our collective knowledge on some rapidly evolving fields of research.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

M-AP: Methodology, Data curation, Validation, Supervision, Conceptualization, Writing – review & editing, Formal analysis,

Writing – original draft. A-JD: Visualization, Data curation, Resources, Investigation, Writing – review & editing, Writing – original draft, Software. GC: Writing – review & editing, Supervision, Writing – original draft.

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Conflict of interest

M-AP is the medical director and co-founder of Clinique des Festivals, a non-for-profit organization dedicated to offering medical care for mass gathering events as well as guidance and counseling to event planners. He did not receive any funding for this research. A-JD is the co-founder and director of events for Clinique des Festival, a non-for-profit organization dedicated to offering medical care for mass gathering events as well as guidance

and counseling to event planners. She did not receive any funding for this research.

The remaining author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The author(s) declare that no Gen AI was used in the creation of this manuscript.

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