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Risks threatening the health of people participating in mass gatherings: A systematic review

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Abstract:

CONTEXT: Mass gatherings (MGs) are established for different religious, social, political, cultural, and sport motivations. Many risks threaten the participants' health in MGs for different reasons. One duty of health-care system is to identify the risks and manage them to reduce the participants' injuries in MGs. This study aimed to identify and classify the risks threatening the health of participants in MGs and review related articles systematically.

SUBJECTS AND METHODS: In this study, we investigated electronic databases including Science Direct, PubMed, Ovid, ProQuest, Web of Science, Scopus, and Google Scholar. This systematic review investigated those health articles which studied MGs published after 2000. Keywords that were searched included (Mass gathering OR Crowd) AND (Assessment OR Evaluation) AND (Disaster OR Emergencies) AND (Injuries OR Stamped). The final full text articles were assessed qualitatively by STROBE article assessment checklist, and then the data extracted from the results of the articles were analyzed and reported.

RESULTS: Initially, a total of 1874 articles were found, qualitative exclusion and inclusion criteria were applied, and finally 29 full-text articles were selected for the analysis. More than forty health-related risks were recognized. In order to better understand the risks and use of the results more efficiently, the risks were classified and reported into the following five domains: environmental risks, individual risks, psychological risks, public health risks, and management risks.

CONCLUSION: Many risks threaten the health of participants in MGs. Recognizing and managing the risks are considered the primary and basic essentials of health sector for the better management of MGs.

Keywords:

Health, mass gatherings, risk assessment, risk evaluation

Introduction

Mass gatherings (MGs) are held for religious, social, cultural, political, and sport reasons, and they harbor health risks and events. Over the past decade, concerns have increased about health-related risks.^[1] According to the World Health Organization (WHO), a MG is a planned or unplanned event in which planning and

responsible resources are under pressure at local, state, or national level due to the large number of people.^[2]

The main concerns of health-care system in MGs include infectious diseases such as diseases transmitted through the respiratory system, foodborne diseases, waterborne diseases, injuries, car crashes, heat exhaustion, insect bites, noncommunicable diseases, and terrorism.^[3]

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Most gatherings reported communicable diseases, noncommunicable diseases, injuries due to stampede, and terrorist attacks to cause high death rates.

In addition to the endemic and seasonal diseases (due to water, food, and respiratory diseases), the health system is faced with muscle strain, dizziness, headaches, asthma and respiratory problems, limb amputation, heat stroke, and abdominal pain, all of which demand special care.

Indeed, these events are considered complicated health challenges locally, nationally, and internationally.^[4] Studies on health system response in Hajj MGs, a great MG, reported influential factors of health system's response such as gathering size, population density, weather, and amount of health facilities available to participants.

Hajj clinical issues are classified into communicable and noncommunicable diseases. Concerning communicable diseases, concerns include communicable respiratory and digestive diseases. However, in noncommunicable diseases, the health system encounters health problems such as accidents arising due to population pressure, fire events, terrorism, and heat exhaustion in Hajj customs.^[5]

In addition to the abovementioned issues, the participants in MGs will face some psychological changes, and these changes may have a negative impact and consequently cause some risks to people's health.^[6] The statistics throughout the world report various risks of MGs. Considering Hajj customs, 1426 individuals died in 1990, 270 in 1994, 118 in 1998, 35 in 2001, 14 in 2003, 251 in 2004, and 3 in 2000 from thirty countries.^[7] Meanwhile, other statistics reported that 249 people were injured at a stadium in Britain in 1989, 249 in a religious ceremony in India in 2008, 450 in a bridge accident in Cambodia's capital in 2010, and 89 in a temple in India were injured due to pressure from the population mass.^[8]

In this regard, the goal of the health-care system is to provide services to population in MGs, prevent and reduce injuries, prevent and reduce disease infection risks, and increase the safety level of the participants. The health system is faced with immense and complicated challenges to reach their objective.^[9,10]

When numerous people gather in a defined place, they are threatened by different health problems. The risks of gatherings are related both to the participants' number and different factors.^[11] Disaster risks associated with MGs are directly related to the existing hazards, exposure level, and vulnerability of the population and environment.^[1]

In order to provide efficient health resources and equipment, managers of MG administrators should

have reliable data about the different aspects of gathering establishment.^[12] Most injuries of individuals in MGs originate from lack of risk management strategies.^[8,10]

For proper management of MGs and to fulfill preventive thoughts and risk reduction, risk factors and health risk potentials in MGs should be recognized in the first step so that a comprehensive risk assessment is performed. In other words, one can analyze and evaluate risks after recognizing them and study the occurrence of events and the effects on the participants.^[8,10,13,14]

Accordingly, this present study was designed to identifying the risks that threaten the health of people participating in MGs. Moreover, we aimed to classify these risks in a clear domain for better perception.

Subjects and Methods

In this study, we investigated electronic databases including Science Direct, PubMed, Ovid, ProQuest, Web of Science, Scopus, and Google Scholar. Keywords including MG, disaster risks, disaster, stampede, and assessment were searched. In order to conduct a comprehensive search, (Mass gathering OR Crowd) AND Risks (Assessment OR Evaluation) AND (Disaster OR Emergencies) AND (Injuries OR Stampede) were used in all database searches. Inclusion criteria of the study included articles in English, published after 2000 with full text. On the other hand, exclusion criteria involved non-English published articles and those published before 2000, articles with lack of full text, review articles, and books.

Data extraction

In order to prevent any bias in the study, data extraction and qualitative evaluation of the articles were accomplished by two independent researchers. Thus, two separate forms were designed. The first one included general information of the articles including publishing year, study year, type of MGs, type of participants in gatherings, methodology of the article, and finally health risk factors reported in the study. The second form evaluated the articles qualitatively; for this reason, STROBE 22-item standard checklist was used.

Results

A total of 3103 articles were identified in the first survey by keywords in international resources. Furthermore, 355 more articles were added in manual Google Scholar research. As a result, the first survey included 3458 related articles, of which 1584 articles were removed due to being duplicated. After reading the abstract of

1874 articles, 1838 articles were excluded. Most studies excluded were review articles, editorial letter, and those with no available full text.

Consequently, 36 related articles entered the study for full-text evaluation based on the inclusion criteria. In this step, 7 articles were excluded after reviewing the full text as the results reported in them were irrelevant. Finally, 29 articles were included in the present study for data extraction.

Figure 1 depicts the flow diagram representing the way in which the articles were identified in this study based on the PRISMA flow diagram.

After qualitative evaluation of the final articles and studying their full text, the information and results extracted are presented in Table 1. In this table, in addition to the general information in the article, the health risks in MGs are presented for each study.

According to the results, more than forty risks were recognized to be threatening the participants` health in MGs.

Table 2 summarizes the extracted risks of articles according to individual domains. To better recognize the risks and for better analysis and understanding, the risks were classified into the following five domains: environmental risks such as heat, cold, humidity of environment; individual risks such as age and sex; risks related to public health such as water and food health; psychological risks such as participants` behavior and risks associated to MGs; and management risks such as risk assessment and availability of caregiver personnel. Note that some of the risks overlapped in two or three domains, and thus were included in the dominant domain.

Discussion

Many studies have been conducted on the health of participants in MGs. Most studies attempted to report health risks in a particular gathering or were based on prior models and were studied in one domain. Because our study objective was achieving maximum risk numbers in MGs, using a systematic review of the studies, different risks were recognized which were finally classified into five domains based on risks` type.

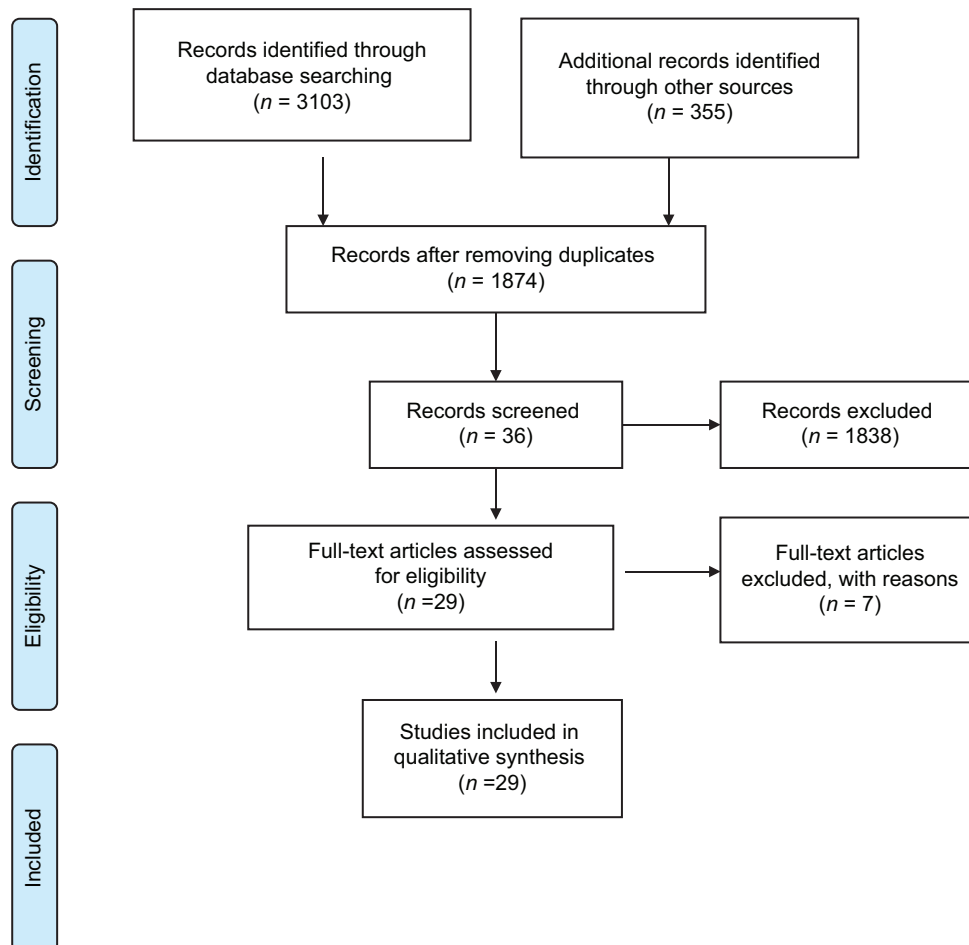


Figure 1: PRISMA flow diagram

Table 1: Health-related risks in mass gatherings based on the articles included in the study

Authors and references	Publication date	Methodology	Mass gathering type	Health risks	Study conclusion
Hutton <i>et al.</i> ^[15]	2012	Pilot study to assess the tool (cross-sectional)	Music festival	Crowd behavior ("jumping up and down"). Crowd mood (energetic). Crowd type (participatory and cohesive). Presence of alcohol and drugs. Crowd density. Temperature and humidity	We need to explore the interaction of MG domains by further research
Perron <i>et al.</i> ^[16]	2005	Retrospective study	Games	Heat index (high)	Cold-related correlation will be researched
Alqahtani <i>et al.</i> ^[17]	2017	Cross-sectional surveys	Hajj, religious	Lack of some pilgrims' awareness about the risk of accidents such as stampedes	In the pretravel briefing, injuries and personal safety must be mentioned
Bledsoe <i>et al.</i> ^[18]	2012	Retrospective, observational	Art festival	Lack of paramedic or physician. Attendance size. Significant distance. Austere environment	Our experience is useful for similar event
Sokhna <i>et al.</i> ^[19]	2017	Cross-sectional	Socio-religious	Road traffic accidents, heatstroke, terrorist attacks, cholera outbreak, infectious diseases	In the context that available medical resource is limited, international collaboration is needed
Selig <i>et al.</i> ^[12]	2013	Observational, retrospective	Race weekend	Weather factors such as temperature, precipitation, and humidity	Weather data influence the use of medical services
Dong <i>et al.</i> ^[20]	2017	Cross-sectional report	New year	Density of crowd, lack of flow direction, lack of self-protection awareness, environmental factors, lack of risk assessment, and lack of surveillance system and communications	Government must improve the fast emergency reaction in MG events
Feldman <i>et al.</i> ^[21]	2016	Retrospective, cross-sectional	Games	High temperatures	Individual education has an important role in prevention and improvement behaviors
Ma <i>et al.</i> ^[22]	2002	Cross-sectional	Games	Alcohol consumption	Alcohol drinking was responsible for most events
Alqahtani <i>et al.</i> ^[23]	2016	Cross-sectional	Hajj, religious	Lack of pre-event advice	We have to progress the participants' awareness and have better communication with them
Gocotano <i>et al.</i> ^[24]	2015	Lessons from the field	Religious visit	Cold weather	Information accumulation from the venue is important to event assessment
Blumberg <i>et al.</i> ^[25]	2016	Cross-sectional	Sport event	Lack of pretravel vaccination. Lack of surveillance system	To encounter communicable disease, enhanced surveillance system is needed
Joseph <i>et al.</i> ^[26]	2016	Cross-sectional	Religious	Human stampedes, person-to-person communicable disease, lack of coordination, shortage of paramedical staff, difficulty in access to medical facilities	The findings are useful for any health sector for risk factor assessment in MGs
Cariappa <i>et al.</i> ^[27]	2015	Lessons from the field. Cross-sectional	Religious	Quality assurance of food and water, disease monitoring and surveillance, water sanitation, disposal of solid and liquid waste, allocation of medical resources	MG management requires modern medical services, sufficient funding, planning, and preparation
Hutton <i>et al.</i> ^[28]	2010	Cross-sectional	Mobile MG	Access to food and water, overcrowding	Health is an important issue in young minds who participate in MGs
Memish <i>et al.</i> ^[29]	2015	Cross-sectional	Religious (Hajj)	Crowded conditions	International MGs can provide a ground for globalization of a pathogen
Shirah <i>et al.</i> ^[30]	2016	Retrospective cohort analysis	Religious (Hajj)	Participants aged >50 years and participants with chronic diseases	Health workers' and participants' adherence to preventive measures is very effective in preventing the spread of diseases
Arbon <i>et al.</i> ^[31]	2001	Cross-sectional. Model creation	All types	Crowd size, weather, mobility of the crowd, availability of alcohol, number of patient care personnel on duty	For better health-care planning in MGs and predicting the rate of patients, we need to model making research

Contd...

Table 1: Contd...

Authors and references	Publication date	Methodology	Mass gathering type	Health risks	Study conclusion
Locoh-Donou <i>et al.</i> ^[32]	2016	Retrospective	Mix (outdoor and indoor)	Outside and unbounded venues, absence of free water, no climate control, percentage of (occupied) seating, increase in heat index	The findings are useful for EMS resource providing before MGs
Kemp ^[33]	2016	Prospective, observational	Not mentioned	Lack of trained and experienced advanced nurse practitioners	Presence of professional nurses to reduce patient referral rates is very helpful
Grant <i>et al.</i> ^[34]	2010	Case study	Multi-day	Gender (female), age (increase)	Must notice at-risk participants
Khan <i>et al.</i> ^[35]	2017	Cross-sectional	Hajj, religious	Old age	Health-care system must improve the knowledge of participants about their health status and preventive measures
Grange <i>et al.</i> ^[36]	2016	Prospective, observational	Motor sports	Lack of on-site physicians	Presence of physician on the venue reduces the patient transportation and EMS workload
Hutton <i>et al.</i> ^[37]	2010	Framework evaluation	Scholes event	Alcohol consumption	Further evaluation is needed to judge this model
Polkinghorne <i>et al.</i> ^[38]	2013	Cross-sectional. Mix method	Music festival	Duration of MG, heat-related ailments	MGs in rural areas are facing more challenges due to limited resource and infrastructure and hence require more comprehensive planning
Balsari <i>et al.</i> ^[39]	2016	Cross-sectional, case study	Religious festival	Density of people, waterborne infection, and disease	To better communicate between the organizations in disasters, we need a incidence command system
Eberhardt <i>et al.</i> ^[40]	2016	Case-control	Sport	Insect bites, sunburns	The risks of participants in sport MGs are different from those of other travelers
Vortmann <i>et al.</i> ^[41]	2015	Mix method	Religious festival	Waterborne disease	As the number of people will increase in the coming years, the likelihood of disaster will increase
Zeit <i>et al.</i> ^[42]	2003	Retrospective analysis	All types	Crowd size, daily temperature, humidity, day of the week	Historical experiences analysis is very useful to design a management framework

MGs=Mass gatherings, EMS=Emergency medical service

The following classification will be useful for better understanding and application of the results in MG management.

Environmental risk domain

In the present study, environmental risks threatening the health of participants in MGs included weather risks such as cold, environmental heat,^[12, 15-42] precipitation,^[12] higher humidity,^[12,15,20,31,38,42] long distance of gatherings and austere environment,^[18] mobility of population,^[31,42] gatherings in outside (external) and unbounded venues,^[32] MGs exposed to traffic accidents,^[19] the participants' number and crowd density,^[15,18,20,28,29,31,39] insect bites, and sunburns.^[40]

An important risk that threatens the health participants in MGs seems to be weather and climate conditions. Specifically, heat exhaustion and humidity as a morbid factor and even death have been reported in MGs.

Heat-related diseases that occur due to long exposure to heat, especially in outdoor gatherings, can be reduced.^[43] Administrative managers should provide facilities such

as adequate shade structures, chiller, cooling station, and sprinkler as well as methods to control the population to prevent such risks.^[5,43-45] Furthermore, insect and arthropod bites were reported as health-threatening risks in the World Cup 2014 in Brazil. The participants are told to wear suitable clothes and cover exposed areas, while the health-care system had to prepare itself to recognize and treat the affected people.^[46]

Population density is considered the main threat to health risks of the participants in MGs, which causes death and various injuries due to population pressure, trampling, and being strangled.^[5,8,45,47,48] Only in the Hajj ceremony, hundreds of people lose their lives or are injured due to population density and pressure.^[5,7]

In addition, significant statistics of injuries due to population pressure in MGs have been reported in other areas of the world.^[8] Evidence also indicates that increasing population density increases the risk of communicable infectious diseases.^[5,46,48,49] Further, increase in the extension and number of participants will amplify the health risks,^[14] and it has been demonstrated

Table 2: Risks threatening the health participants in mass gatherings based on domains

Domain	Risks
Environmental domain	Crowd density and attendance size, ^[15,18,20,28,29,31,39,42] mobility of population, ^[31,42] high temperature ^[12,15,16,19-21,31,38,42] and humidity, ^[12,15,20,31,38,42] significant distance, ^[18] austere environment, ^[18] traffic accidents, ^[19] precipitation, ^[12] cold weather, ^[24] outside (external) and unbounded venues, ^[32] insect bites, ^[40] sunburns ^[40]
Psychological domain	Crowd behavior (jumping up and down), crowd mood (energetic), and crowd type (participatory and cohesive). ^[15] Presence of alcohol and drugs ^[15,22,37]
Individual domain	Lack of awareness about the risk of accidents, ^[17] lack of self-protection awareness, ^[20] participants with chronic disease, ^[30] gender (female), ^[34] age (increase) or old age ^[30,34,35]
Public health domain	Probability of outbreak and pretense of infectious disease, ^[19,26,41] quality assurance of food and water, ^[27] water sanitation and hygiene, ^[27,41] disposal of solid and liquid waste, ^[27] lack of disease monitoring and surveillance system ^[20,25,27]
Management domain	Lack or shortage of paramedic or physician or patient care personnel on duty, ^[18,26,31,33,36] terrorist attack, ^[19] lack of flow direction, ^[20] lack of risk assessment, ^[20] lack of disease monitoring and surveillance system, ^[20,25,27] lack of communications, ^[20] lack of pre-event advice, ^[23] lack of pre-event vaccination, ^[25,26] lack of coordination, ^[26] difficulty in access to medical facilities, ^[26] allocation of medical resources, ^[27] access to food and water, ^[28] availability of alcohol, ^[15,31] absence of free water (i.e., without cost), ^[32] duration of MG ^[38]

MG=Mass gathering

that mobile populations generated more workload for emergency services than seated populations.^[50] The epidemiological process of spreading diseases depends on factors such as pedestrian population, transportation type, and the duration and spatial extension of MGs.^[51]

It is possible to manage this important risk through pre-event assessment, early warning systems, as well as population management and control methods including population simulating models, participants' grouping, and using novel technologies.^[8,47,51,52]

Risk of sunburn is higher in open-area gatherings. In addition to the short-term effects such as skin reaction, heat exhaustion, and dehydration, the light radiated from the sun causes other consequences such as cataracts and skin cancer. The participants should be trained about wearing suitable clothing, using sunscreens, and, as far as possible, moving and remaining in shady spaces.^[53,54] In unbounded MGs, controlling the venue capacity is very difficult. Instead, in bounded venue like a stadium with fixed seats, planners have some control over the number of participants.^[55] Traffic accidents and being drawn were reported as fatal causes and injuries of participants in the summer Olympics in Greece. Furthermore, a portion of injuries of Hajj participants were due to traffic accidents.^[45,54]

It is suggested that participants in gatherings pay more attention to warnings in the field and be trained about safety measures.^[54]

Public health risk domain

In public health domain, risks that threaten the participants' health in MGs extracted from the study included probability of outbreak and spread of infectious diseases,^[19,26,41] unsuitable sanitation and hygiene of water and improper food quality,^[27,41] improper disposal of wet and dry waste,^[27] and finally lack of disease monitoring and surveillance systems.^[19,25,27]

The risk of spreading infectious diseases including respiratory tract infections, gastrointestinal infections, and skin infections is increasing in MGs.^[5,45,56] Control of communicable diseases in the mass rallies is a very critical challenge because the outbreak of a disease in MGs can be a precursor to its spread to the entire community.^[57]

In international MGs, a disease outbreak such as flu and measles is rarely seen due to vaccination protocol for diseases, while the outbreaks have mainly focused on gastrointestinal diseases. This fact further illustrates the importance of efforts on water and food health of the participants.^[58] In addition, it was observed that the outbreak of waterborne disease with various pathogens (parasites, bacteria, and viruses) occurred due to the lack of personal and public hygiene and insufficient vaccination coverage.^[58] Further, in addition to water sanitation, similar supervision should be considered for ice sources as well.^[56] Due to the provision of safe drinking water during the Hajj, the risk of waterborne diseases is low. However, the use of ice cubes from unknown source for cool water and beverages has increased the risk of contamination.^[59]

A vaccination program can reduce the incidence of infectious diseases, especially in international gatherings. In gatherings such as Hajj and Olympic games, a suggestive vaccination protocol should be designed, based on endemic disease, the participants' conditions, and other specific factors.^[13,49,56]

The country which hosts MGs should consider necessary planning based on its endemic communicable disease to reduce epidemic risk. Participants who travel to areas with higher prevalence of malaria should be assessed and if necessary, prophylactic treatment should be done according to the protocol. In addition to designing instructions for endemic and seasonal diseases, it is

useful to have a preventive plan and disease monitoring system.^[46]

Other studies suggested that recognizing the disease, reporting it, and monitoring system are necessary for disease diagnosis and preventing breakout.^[5,48,54,56,60,61] Furthermore, disease surveillance systems can be useful and effective in the recognition of bioterrorism attacks.^[54,60]

Inappropriate management of public and environmental health in MGs threatens the health and welfare of the participants and staff. Health managers have to notice the essential needs of individuals such as adequate public toilets, sufficient cooling devices for frozen food, health food supplies, facilities for dry and wet waste disposal, and insect and rodent control.^[51]

Individual risk domain

In the present study, individual risks threatening the participants health in MGs included lack of awareness about the risk of accidents,^[17] lack of self-protection awareness,^[20] participants with chronic disease,^[30] as well as women's and elderly's presence.^[30,34,35] Handwashing, using mask, and maintaining distance from others were considered as preventive factors; although for participants, especially the elderly, the use of masks was considered difficult in hot weather.^[62] However, it is difficult to maintain social space and avoid contact with other participants in MGs, in this reason. Personal preventive activities such as mask utilization and handwashing may be suggested.^[63]

The risk of presence of elders in MGs seems to be related to both chronic disease and inability for self-protection, which is a threat to their health.

According to suggestions of the WHO in Hajj, people aged above 65, those who are affected by a chronic disease, pregnant women, and children aged below 12 should receive vaccine injection according to the protocol and engage in more protective measures such as using a mask, washing hands, and keeping a distance from others.^[64] Meanwhile, many articles reported deaths due to heat loss of the elderly and those due to the underlying disease.^[5]

In walking gatherings, the groups with men and women in comparison to groups with only men had a lower moving speed, more population distance, and more population gap.^[65] Risks related to individual risks indicated that authorities of MGs should cover information of participants such as age, sex, existing disease, awareness, and education level before gatherings so that necessary predictions can be provided accordingly.

Psychological risk domain

In this systematic review, the psychological risks threatening participants' health in MGs included crowd behavior (jumping up and down), crowd mood (energetic), and crowd type (participatory and cohesive),^[15] as well as alcohol or drug consumption.^[15,22,37] On this basis, in the psychological domain, MGs with alcohol presence, jumping up and down (crowd behavior), energetic (crowd mood), and participatory and cohesive (crowd type) characteristics had the most risks.

The types of MGs influence the behavioral risks of people. For example, risks of a rock music concert are different from those of the Hajj. Meanwhile, failure in the successful implementation of other dimensions of health in MGs will cause stress in participating individuals and change their psychological status, thereby creating further risks.^[6] Population behavior is affected by excitement such as fear, anger, and passion. Such excitement may reach an extreme level under particular conditions and be inducted to the whole population contagiously. Therefore, psychological conditions of the participants may result in intensified effects on the safety of population.^[52] Knowing factors that result in behavioral change of people and consequently behavioral changes in the population is crucial. One of them is alcohol consumption by individuals.^[53,66] In a review by Steffen *et al.* entitled "noncommunicable health in mass gatherings" in 2012, alcohol and drug consumptions were reported as noncommunicable risk factors in MGs, resulting in trauma and poisoning.^[4] Crimes are reported less in Hajj gatherings due to lack of alcohol and drug consumption.^[67] In music festivals involving alcohol consumption, there is an increased risk of sexually transmitted disease risks.^[58]

Considering the psychological condition of the participants, identifying risks and recognizing psychological changes of the participants and the population in MGs play a key role in the domain management. Behavioral change in a part of the population may be considered as a spark to changes in the behavior across the entire population. The population behavior and resulted changes should be studied to prevent the associated risks.

Through risk assessment before gatherings, health-care systems recognize the risks and prepare for the required provisions to confront probable events.^[53,66] Furthermore, risks associated with alcohol consumption can be minimized in MGs by forbidding alcohol and drug use.^[4,44]

Management risk domain

In this study, the risks due to lack of support on resources and inefficiency of gatherings' safety recognized in this

domain were reported as Lack or shortage of patient care workers such as Physicians or Paramedics;^[18,19,26,31,33,36] flow directions;^[20] risk assessment;^[20] communication;^[20] pre-event advice;^[23] a plan for vaccination before gatherings;^[25,26] coordination;^[26] free water as well as terrorist attacks; difficult access to water and food;^[28] difficult access to medical facilities;^[26,27,32] and duration of MG.^[38]

One of the factors reducing the health risks in MGs is the presence of expert medical care staff in MGs including physicians, nurses, and emergency technicians. Presence of medical care staff not only speeds up medical handling but also prevents unnecessary dispatch of ambulance to health-care centers.^[68]

Inability to manage the population leads to inadequate access of emergency personnel to the required areas.^[51] Therefore, presence of emergency and medical care staff is not sufficient to reduce health-related risks; it is necessary to have separate safe entrance and exit gates for participants in addition to recognized ways for emergency and medical care staff to access all areas in the gatherings.

There are different reports concerning deaths and injuries caused by this problem.^[68] Basic provisions such as plans and practices before gatherings, providing security of place of gatherings, providing radio communication and integrated command and control, being connected to urban and national services, and resource management should be accomplished for emergency staff to access all gathering areas.^[10,69] On the other hand, in gatherings with ticket-selling services, extra ticket sales should be prohibited and population saturation should be prevented through proper notification.^[68] Because of different reasons such as population density and releasing the news out, the gatherings are regarded as suitable targets for terrorist attacks.^[5,54]

Authorities and security forces should consider and practice security arrangements before gatherings as much as possible; the reason is that security measures during gatherings may result in population stimulation and injuries due to population pressure and stampedes. Meanwhile, proper routes of entrance and exit gates should be considered with a particular guidance. This can allow one-way flow of the population at the necessary time.^[68]

In order to prepare for successful implementation of MGs, the health department should practice necessary coordination in all parts. Note that it is impossible to implement health plans without cooperating with other sectors in the country. Therefore, the coordination and cooperation should

be provided in a complete particular plan between the health ministry and other ministries. Necessary coordination, cooperation, and communications with other organizations such as the WHO should be provided in international gatherings.

Efficient methods should be considered to provide coordination to share data and information at all levels.^[13,70] For example, more than 130 health-care centers and 17,000 health-care personnel engage in the Hajj ceremony. It is impossible to manage health-care centers and personnel without planning and a cooperation system. In addition, the health-care system should engage and cooperate with other organizations who are involved in MG management, which requires an effective communication mechanism.^[67,70]

Meanwhile, engaging the participants before gatherings is considered a necessary action which plays a key role in health risk reduction in MGs. The provisions include recommendations and different standard plans for participants^[45,46,48,57,71,72] and vaccination according to approved protocols.^[5,45,46,48,56,58,67,71-73]

The duration of the gathering is another issue that should be considered in MGs. It is reported that increasing the duration of MGs has increased the health risks^[14] and the workload of emergency services.^[50]

Risk assessment is considered a basic pillar of MG management, which plays a significant role in recognizing health risks. Indeed, without recognizing probable risks threatening participants and their extent, it is not possible to accomplish appropriate interventions. Different articles have also acknowledged the importance of risk assessment in identifying and managing health hazards in MGs.^[1,4,10,13,14,44,52,58,66,68,70,72,73]

In this study, we identified the health risks of participants in MGs. In addition, for better understanding and functional use, they are reported in five separate domains and discussed each of them individually. Limitation of this research is that included articles are only in English language.

Conclusion

The risks threatening the health of participants in MGs were extracted in this systematic review from 29 final articles. Due to the considerable number and breadth of the results, the recognized risks were classified into the following five domains: risks related to environment, public health, individual features, psychological conditions, and management. Some risks overlapped in one or two domains which were discussed in the dominant domain.

A successful implementation of MGs and reducing risks related to people's health requires attention to all recognized risks and integrated management, as neglecting a risk may threaten the health of all participants.

While different risks threaten the health of people in MGs, operating a MG may result in recognizing the problems and shortages of health-care system, leading to creativity and passion of staff, thereby providing a chance to develop health plans, personnel training, evaluation of the health-care system, as well as testing communication systems along with inter- and intra-coordination.

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Conflicts of interest

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