Mass Gathering Emergency Medicine: A Review of the Taiwan Experience of Long-distance Swimming Across Sun-Moon Lake

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SUMMARY

Once a year during the festival of Sun-Moon Lake in Nan-Tou County, Taiwan, a long-distance swimming mass gathering (LDSMG) event takes place. This event, in which participants swim an estimated 30 km, is very popular; the total number of spectators and participants at the 2002 festival was 15,189. This study, the first pertaining to the LDSMG, aimed to review the effect of the environmental factors at this particular mass gathering event, with mass being defined here as more than 1,000 people, upon the event's patient presentation rate (PPR). This was done to provide improved medical services at this event in future years The study also aimed to collect patient data from the two medical stations (one upstream and one downstream) and analyze the differences between them. In 2002, the number of patients requiring first aid treatment was determined from data gathered on-site. A total of 63 presented at on-site medical stations (PPR, 4.15 per 1,000 attendees), where 14 patients presented to a downstream medical station and 49 to an upstream medical station. The mean age of the patients was 35.46±15.14 years; ages ranged from 1 to 65 years. Forty-nine of the patients (78%) were male. Fifty-nine patients were treated with medication (3.88 per 1,000 attendees), and two were taken to hospital (0.13 per 1,000 attendees). Injuries sustained included trauma (71%), such as impact, fall, sprain, stabbed laceration and burn, hypothermia (5%), and foreign bodies (3%). The PPR at the LDSMG was related to factors including the presence or absence of seating, whether the event was outdoors or indoors, mobility of the crowd, whether the activity was contained within a boundary, attendance figures, and humidity level. The weather, particularly the relative humidity (81%), was also positively correlated with an increase in the number of presentations at the medical stations. [International Journal of Gerontology 2010; 4(2): 53–68]

Key Words: emergency medicine, mass gathering, patient presentation rate, physical endurance, swimming

Introduction

Mass gatherings (MGs) are characterized by large crowds of people attending an event. To qualify as an MG, the crowd should exceed 1,000 persons[1–6], although others have argued that the number that should be exceeded is 25,000 before an event is an MG[4]. Such events are increasingly common worldwide.

MG medical care (MGMC) is concerned with the provision of emergency medical treatment at these organized events. However, the provision and delivery of such treatment can be poor because of our lack of understanding of the resources needed[1–6]. MGMC is an under-researched and under-discussed area.

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A study by Mears and Batson[7] has addressed the importance of enforcing emergency medical services (EMS) planning and training to resolve existing problems with MGMC. The primary cause of these problems is a combination of the high degree of environmental variability that exists between different MG events, and the minimal epidemiologic data that is available[8–10].

Millions of people attend MG events every year in the United States[1,11]. Whilst most of the medical services needed at these events are for the treatment of relatively minor injuries and ailments, it is, nevertheless, important that the EMS are equipped and prepared to deal with any sudden life-threatening conditions effectively, should they arise. The main problem for MGMC providers has been the lack of any standard practice guidelines[2,3].

The many variables associated with MG events have made the implementation of plans and guidelines very difficult, and many of the sources that offer such plans and guidelines conflict[2,12,13]. Variables at MG events that could feasibly influence the MGMC requirements of a given event include: (1) the weather (temperature and humidity); (2) the duration of the event; (3) whether the event is predominantly outdoors or indoors; (4) whether the spectators and participants are predominantly seated or mobile within the venue; (5) whether the event is bounded (fenced or contained) or unbounded; (6) the type of event; (7) the total number of people and crowd density; and (8) the placement of the medical station(s) at the venue[14].

Appropriate emergency medical care becomes ever more necessary with the increasing frequency of MGMC[3,15]. The incidence of illness and injury at such events remains higher than that found in populations of similar size which are not gathered[16].

MGs in Taiwan

The swimming festival of Sun-Moon Lake is held by the government of Nan-Tou County in Taiwan. Sun-Moon Lake is estimated to be over 30 km across (Figure 1). Attendance at the festival increases significantly each year. In 2002, the total number of spectators and participants was 15,198 (Figure 2). Nan-Tou is an area that lacks medical resources. There are only two mid-sized 300-bed hospitals in the county. The shortest time in which citizens can expect an ambulance to transport them from Sun-Moon Lake to the hospital is 40 minutes.

Figure 1. Sun-Moon Lake in Nan-Tou, Taiwan.

Figure 2. Mass gathering activity across Sun-Moon Lake (long-distance swimming is defined here as any open-water swimming event in which participants swim up to a maximum of 30 km).

Sun-Moon Lake is in mountainous terrain, which is a considerable distance from urban areas, and is hard to access, both in terms of traffic and communication. The area lacks water, power, food supplies, and shelter. Therefore, MGMC is a major concern of this festival.

No previous research has specifically addressed the EMS at MG long-distance swimming events across Sun-Moon Lake. Providing an adequate medical service for this event represents a significant challenge. The risk of injury increases with the number of participants and the intensity of activity around the lake during the event. In previous years, EMS for this large-scale event was not taken seriously by the sponsors, who did not believe that there were any serious risks involved. However, the importance of medical aid services for this event has

been taken more seriously since some swimmers died in 1997.

The Health Bureau in Taiwan had previously intended to address the issue of health care in this region, in view of the Health Bureau's plan to double the number of tourists to the area over the next few years. However, considering the evident effects of the increasing number of participants in the lake swim, this is a matter that urgently needs to be resolved. An MGMC needs to provide on-site event medical care and preserve the abilities of the EMS system to provide its services[17]. On-site medical care includes rapid access to the patient, triage, stabilization, and transport without delay to definitive care, as well as treatment of minor injuries and illnesses[5,16,18]. The other purpose of MGMC is to respond to an emergency situation, such as sudden cardiac arrest, as soon as possible. Correct triage between minor complaints and serious injuries are necessary to determine the need for advanced treatment or transport to an appropriate location. The functional aim for the local EMS is to have on-going access when MG events are taking place. The local EMS also provides extra help and part-time personnel for medical care required at a large event[19,20].

It has been reported previously that the workload of the EMS is reduced when physicians are on scene to react at MG events[14,21,22]. Physicians are becoming more important in the planning and implementation the medical service. In addition, the data collected and accumulated from similar types of events allows appropriate preparedness.

The goal of this research was to collect data on various environmental factors at the Sun-Moon Lake festival and on the accidents and ailments dealt with by MGMC, and to determine any correlation between the two. Another goal was to provide enough information relevant to this specific event for proper planning of MGMC practices and resources in order to deal most effectively with the medical issues that may occur.

Literature Review

In 1991, Hnatow and Gordon[23] reviewed the 1987 San Antonio Papal Mass and thus applied a useful critical approach to the analysis of an MG. First, they clearly articulated the purposes of the services provided, identified the lack of reliable tools for predicting patient presentation rates (PPRs), and considered the environment in which the event occurred. They then attempted to estimate the crowd size and medical services and staff specifically required for the event. In 1997, De Lorenzo[4] published a paper that challenged researchers to address the key issues in the provision of an effective medical service during MG events. In this review, De Lorenzo noted the absence of uniform service standards and the wide variations in casualty rates for similar events. The factors that appeared to explain this wide variation between events included event type, weather, and differences in the data collection techniques employed.

De Lorenzo[4] highlighted the principal goals of MGMC as: (1) establishing rapid access to injured or ill patients, and providing triage; (2) providing effective and timely stabilization of and transport to hospital for seriously injured or acutely ill patients; and (3) providing on-site care for minor injuries and illnesses.

In the same year, Michael and Barbera[17] reviewed 25 cases that had been published over the preceding 25 years on the provision of medical care at MGs. They found that variations in the effectiveness of MGMC systems were related to the type of event, the country, the weather, and the size of the gathering. Previous studies demonstrated a significant effect of environmental factors on casualty presentations[23,24]. In addition, the authors identified the need for a standard classification scheme that would allow an early analysis of the causative relationships between the features of a specific MG and the type and number of presentations, thus allowing medical personnel to predict the requirements of an effective service at any given event. They suggested that the collection of data from individual events could provide the basis for prediction of PPR across different types of events and different venues. The authors defined MG events as focused or extended, and bounded or unbounded. If an event was held in a clearly defined venue/location, then it was classed as focused. Events not focused in a single location, such as marathons and parades, were classed as extended. An event was described as bounded when it was contained within a boundary, often fenced. Conversely, events that were not contained in this way were described as unbounded. It was noted that bounded events could be expected to have a higher PPR, with a particular likelihood of a higher incidence of minor illnesses and injuries. This may be because first aid and medical services are often more visible in such a setting and there is less likelihood of patients going to nearby medical facilities.

The majority of MG events in the studies reviewed were bounded/focused or unbounded/extended events. In all samples of MG events, respiratory illnesses, minor injuries, heat-related injuries, and minor problems such as headaches, blisters and sunburn comprised 75% of patient presentations[25]. Among those patients who required acute intervention, asthma was the most common complaint. Outdoor events produced a higher incidence of environment-related injuries, such as abrasion, contusion, laceration, and sunburn. Crowd mood events, such as rock concerts, which attract large numbers of young people, were associated with a greater number of medical problems arising from alcohol and drug use. Exhausting events can induce sudden cardiac arrests, although this occurs relatively infrequently (1 per 500,000 at Australian rules football); therefore, on-site cardiac resuscitation and defibrillation is considered important and can improve patient survival rates[26]. The reviews of Michael and Barbera[17] have addressed the relationship(s) between the previously identified environmental factors and PPR by demonstrating the requirements for first aid care at major public events. The environmental factor found by these authors to have the greatest effect on patient load was crowd size. Bowdish et al.[27] has proposed a model to explain the differences that occur in PPRs in MGs of analogous size, based on the parameters of weather, alcohol use, availability of medical care, the nature of the event, injury or illness type, crowd mood, and the average age of the participants/spectators/audience. Transportation of patients from on-site medical stations to local hospitals requires a ground ambulance (or, occasionally, an air ambulance), and the difficulties associated with both vehicular and pedestrian traffic congestion at large gatherings may require standby ambulances located at the event to travel out. Transportation to hospital rates (number of patients transported to hospital per 1,000 persons in attendance; TTHR) were found to range from 0.01 to 0.55. This correlated with the rate at which medical or first aid services were used by patients, which varied from 1.6% to 26.7%[25].

Before the swimming festival of Sun-Moon Lake, course preparations and risk assessments are undertaken by the organizers. The organizers ensure that the competitors are not placed in any danger as a result of the location or condition of the water.

There are a number of factors that need to be considered and documented, including the area used for an MG swimming event. These include its location, the water conditions, and whether it is to be a sea, lake or river swim. The organizers should assess the condition and proximity of the start and finish points, evaluate water temperature, consider potential currents, and steer the intended route away from any hidden, overhanging or underwater hazards.

Access to the area and an on-scene medical station are very important, as this will determine not only how each event should take place, but also, in the event of an emergency, how the EMS would gain access to the start and finish areas, and to the course. The course design should aim to create minimal congestion at the race start, and the start and finish areas should be clearly defined. The start must be wide enough for the proposed number of participants to make a safe start, free from interference from others. The finish area should be marked so that there is no confusion as to exactly when the course is completed.

The actual swim course should be marked with buoys that are clearly visible in the water. Turn buoys should be at least 1.5–2 meters high in the water. All markers should be fixed so that they will not move in the prevailing water conditions or at turn of the tide. A lead boat or canoe may be required for the leading swimmer. Swimmers should be required to wear a numbered, brightly colored swim vest.

There is a lack of standardized guidelines for the provision of medical services at MGs[4], and there have been few published works on general standards for patient care services at such gatherings. Despite the fact that some guidelines are official legislation, they are still used extensively[28–31]. This medical workload has been noted in the few studies reviewed here on the delivery of patient care services at MGs[32].

The study by Arbon et al[33]. has provided a method for predicting the medical care requirements at any given MG based on information gathered from a range of such events. This method appears to be an accurate means of making these predictions[33]. However, the predictability is restricted to 1 day. Arbon et al.[33] found that the predictions of patient presentations were more accurate when the data were reviewed and collected retrospectively and more completely after the specific events. In addition, individual variability is very event-specific[33]. A regression analysis was used for organizers to develop models that would support the prediction of PPRs and TTHRs at future events. The TTHR and PPR are examples of an emerging common language[26,33,34]. The key features of casualties in terms of rate and type

of presentation have been considered for a range of severities of patient presentations. As the literature has shown, respiratory illnesses, minor injuries, heat-related injuries, and minor problems such as headaches, blisters and sunburn make up 80% of the casualties[33]. An MG study in Australia found that asthma attacks (3%) were the most common complaint among those requiring acute interventions[33]. Outdoor events appear to bring more environment-related injuries such as lacerations, contusions, and sunburn. As Wassertheil et al.[35] have shown, crowd events such as rock concerts that attract young people lead to more alcohol- and drug-related problems. Cardiac arrest presentations occurred very rarely in a study on Australian rules football events. Nevertheless, on-site resuscitation and early defibrillation are important when such attacks do occur and can improve patient survival rates[35]. Differences in patient presentations appear to be associated more closely with key features of events, such as weather and the nature of the activity[35].

Materials and Methods

Safety craft and/or canoes must be provided. Personnel should be assigned to water safety at a ratio of one to every 20 competitors. Emergency exit points should be marked where swimmers can leave the water. Organizers should consider shortening or canceling a swim if the water temperature falls below 16°C. Excessive water flow or wave conditions should also contribute to any decision of this kind, as should deterioration in weather conditions. The water or air temperature, and the humidity should be recorded as a routine aspect of the regular rules at the start. For all swim events, alternative plans should be made in case environmental factors make the swim unsafe, forcing it to be cancelled or curtailed. The maximum safe number of swimmers in the water at any one time should be determined. In addition, safety craft should be employed carrying first aid and warming facilities. Even when the water temperature and air conditions are good, it is advisable to have additional resources at the swim exit. As several factors have been found to influence the number and type of patients presenting at MGs, this study was designed to gather data on several of the environmental factors that are considered significant influences on PPR and THR. This prospective study collected the details of casualties presenting along with other variables such as crowd age, profile, temperature, humidity, the number of patients transported to hospital, and the qualifications and number of medical personnel. The method of study was developed to incorporate data from the first aid transportation service to local hospital emergency rooms, and from those personnel providing essential on-site treatment. This information was collected by a survey, administered to these personnel on the medical details of accidents at the MG event studied.

The medical service records listed the patient's basic information, the time of attendance, the triage level, vital signs, the location of wounds, the mode of injury, the chief complaint, the final diagnosis, the treatment or medications administered at the scene, and details of transportation to hospital, a clinic, or home. The staff were well-trained and skillful. They were responsible for the whole organization and for whoever was present on-site, for cooperation between the medical stations, for communication with the other MG organizations, and for treating injuries. The enrolled patients were from the total participants, spectators, local residents, and staff at the event. No age limit was set for patients on whom data was collected.

On the day of the event, the two medical stations were set up on land to rescue any participants in emergency situations; one was located near the start and was staffed by personnel from Puli Veterans Hospital of Taiwan, which provided eight medical aid personnel and one ambulance. The other medical station was located in an upstream position and was staffed by personnel from Puli Christian Hospital, which provided 11 medical aid personnel and one well-equipped ambulance. Long- and short-distance wireless medical service communication was established and there was long-distance fax communication on-scene. In addition, there were several lifeguards in the aquatic medical main terminal in front of the upstream station, and these were provided by the Red Cross Society of the Republic of China. All medical personnel at both sites completed the survey. Approximately every 100–200 meters along the swim course, there was an aquatic first-aid station to enable contact with the medical service in an emergency. The water transport equipment included an aquatic skiff and a medium-sized lifeboat to pick up urgent or sick cases. There was also a large-scale transportation craft that went back and forth to pick up swimmers who wanted to give up or were exhausted. The MG activity took place from 7:00 am to 3:00 pm.

Results

In total, data was collected on 15,198 event participants. The climate temperature was 32°C, and the water temperature was 22°C. The humidity on the day of the event was 81%. During the period that the two medical stations were in operation (from 7:10 am to 13:10 pm), 63 patients were treated. The patient data are presented in Table 1. Patients comprised 54 swimmers, three spectators including families, two members of event staff, two members of medical staff, one local resident, and one unidentified person. Of these, 49 were male and 14 female. Of the 63 patients, one patient (2%) was classified into triage level 1, with fatigue resulting in near drowning and rescue, and was treated at the upstream medical station at 13:02. Seven patients (11%) were level 2, 16 (25%) were level 3, and 39 (62%) were level 4. There were few severe cases in these patients and none died (Table 2). The average age was 35.46 ± 15.14 years (range, 1–65 years). There were larger numbers of young adults rather than children or elderly participants (Figure 3).

The total PPR was 4.15 per 1,000 participants. There were 14 patients (22%; PPR, 0.92) treated at the start (or downstream) medical station and 49 (78%; PPR, 3.23) at the upstream medical station. Of the 63 patients, 59 required further medical resources and treatment, such as iodine sterilization, a dressing package or splinting immobilization. Both the PPR and their medical utilization rate were higher in the upstream medical station compared with the start medical station (Table 3). Among the 14 patients at the start medical station, two patients were advised not to go in the water. One patient with a cardiovascular history was seen at 7:10 am, and had upper abdominal pain before entering the water, which subsided after a dose of antacid. Another patient, who was seen at 7:30 am, had experienced an accident resulting in a puncture wound to the head. This patient was treated with an iodine wipe. The PPR per 1,000 attendees was highest during the noon period (11:00–12:00) (Figure 4). The types of wound and sickness, in order of frequency, were abrasion ($n = 32$; 51%), contusion ($n = 7$; 11%), laceration ($n = 10$; 16%), abdominal pain ($n = 3$; 5%), chill ($n = 6$; 10%), headache ($n = 1$; 2%), and near drowning with altered consciousness ($n = 1$; 2%). There were significant minor traumas in these patients (Table 4). The three most common mechanisms of injury in order of frequency were impact ($n = 31$; 49%), fall ($n = 8$; 13%), and conjunctivitis ($n = 4$; 6%) (Table 5). The extremities of the legs were noted as the body part most frequently injured ($n = 16$; 25%) (Table 6). Among the 39 patients who had body temperature measured, five were hypothermic, as defined by a body temperature of less than 34°C. No cases of fever were noted in these patients (Table 7). Although most patients did not have blood pressure measured, one patient was found to be in shock following a complaint of abdominal pain at the upstream medical station at 9:50 am. Blood pressure was recorded as 72/57 mmHg. The patient received no medical treatment and went home after a period of observation.

The top three most frequent treatments were wound sterilization with alcohol wipes ($n = 38$; 60%), homeostasis or bandage ($n = 16$; 25%), and medicinal ointment or eye drops ($n = 12$; 19%). Nonsteroidal anti-inflammatories or antibiotics were given depending on the patient's requirements (Table 8).

Five patients were referred to hospital services, three for a tetanus injection, one for a large laceration to the lower leg, and one for admission and close observation. Of these, two were transported by ambulance and three were taken by their family. All were forbidden to continue participating in the swimming event.

Discussion

Regional emergency medical communication systems affect medical treatment activities at MGs corresponding to the scale of activity and medical resources available. The presence of these communication systems was highly respected in distant areas, especially those with inadequate medical resources.

As noted in the literature, the skill of medical personnel attending MGs has been found to be highly variable. At this event, patient-care providers included 19 with basic first aid (76%), two ambulance officers (8%), and four medical officers (16%). The existing literature has suggested that patient presentations at MGs are influenced by several environmental factors. Crowd size has been found to be an important contributor to the number of patients presenting to first aid and medical services[27]. A positive relationship between crowd size and the number of patients who presented for treatment was shown in the current study. At an event, the expected attendance is a relatively strong predictor of the number of patients presenting who may require treatment[36]. As the crowd size increases, the number

Table 1. *Data on the 63 patients*

Case no.	Age (yr)	Triage level	Sex	Identification	Time	Medical station location	Vital signs				Wound type	Mechanism	Body part injured	Wound treatment	Drug medication	Outcome
							BT (°C)	PR (/min)	SBP (mmHg)	DBP (mmHg)						
1	42	4	M	Staff	7:10	Start	N/A	N/A	N/A	N/A	Abdominal pain	N/A	Abdomen	MO	Gascon, 1 tablet	GH
2	63	4	M	Staff	7:30	Start	N/A	N/A	N/A	N/A	L/W	Impact	Head	a	N/A	RHT
3	26	4	M	Player	7:35	Start	N/A	N/A	N/A	N/A	A/W	Impact	Leg	a	N/A	GH
4	35	4	M	Player	8:02	Start	N/A	N/A	N/A	N/A	L/W, A/W	Impact	Upper limb	a + b	N/A	RHT
5	61	4	M	Player	8:10	Start	N/A	N/A	N/A	N/A	A/W	Impact	Upper limb	a	N/A	GH
6	31	4	M	Player	8:15	Start	N/A	N/A	N/A	N/A	A/W	Impact	Leg	NO	N/A	GH
7	27	4	M	Spectator	8:35	Start	N/A	N/A	N/A	N/A	A/W	Impact	Upper limb	a	N/A	GH
8	28	4	M	Player	8:40	Start	N/A	N/A	N/A	N/A	A/W	Impact	Chest	a	N/A	GH
9	53	4	M	Player	8:55	Start	N/A	N/A	N/A	N/A	C/W	Impact	Upper limb	a + b	N/A	GH
10	1	4	M	Other	9:45	Start	N/A	N/A	N/A	N/A	C/W	Impact	Leg	NO	N/A	GH
11	8	3	F	Spectator	9:50	Upstream	37.3	97	72	57	Abdominal pain	N/A	Abdomen	NO	N/A	GH
12	30	4	M	Player	9:50	Start	N/A	N/A	N/A	N/A	C/W	Impact	Eye	h	N/A	ROC
13	50	4	M	Player	9:52	Upstream	34.2	72	N/A	N/A	L/W, A/W	Stab	Leg	a	N/A	GH
14	58	3	F	Staff	10:00	Upstream	37.1	70	106	88	C/W, A/W	Fall	Leg	a + c	N/A	GH
15	60	4	M	Player	10:05	Start	N/A	N/A	N/A	N/A	A/W	Foot edema	Ankle	a	N/A	GH
16	29	4	M	Player	10:20	Start	N/A	N/A	N/A	N/A	C/W, eye pain	Fall	Leg	c + b	N/A	GH
17	44	3	M	Player	10:23	Upstream	34.4	120	101	89	L/W, A/W	Stab	Left foot	a + c	N/A	GH
18	65	4	M	Player	10:31	Upstream	34.2	66	N/A	N/A	C/W	Impact	Upper limb	a	N/A	GH
19	8	4	F	Spectator	10:40	Upstream	37.1	100	103	68	L/W	Impact	Palm	a + b	N/A	GH
20	29	3	F	Player	10:50	Upstream	32.6	108	112	91	C/W	Impact	Foot	a	N/A	GH
21	32	2	M	Staff	11:04	Start	N/A	N/A	N/A	N/A	A/W, L/W	Impact	Leg	a + b + c	N/A	TTH
22	57	2	M	Player	11:05	Upstream	33.5	115	187	114	A/W, wound pain	Sprain	Leg	a + c + g	N/A	GH
23	11	3	F	Player	11:05	Upstream	34.1	N/A	N/A	N/A	Abdominal pain	N/A	Abdomen	MO	Buscopan, 1 tablet	GH
24	50	3	M	Player	11:05	Upstream	35.1	109	171	113	A/W	Impact	Leg	a + c	N/A	GH
25	39	2	M	Player	11:10	Upstream	36.8	N/A	N/A	N/A	A/W	Impact	Toe	a	N/A	GH
26	26	4	M	Player	11:10	Upstream	34.8	99	146	100	A/W	Impact	Leg	c	N/A	GH
27	47	3	M	Player	11:10	Upstream	34.4	111	125	96	A/W	Impact	Leg, right knee	a	N/A	GH
28	28	4	M	Player	11:10	Upstream	35.2	N/A	N/A	N/A	Vesicle	N/A	Foot	a + b + c	N/A	GH
29	64	4	M	Player	11:15	Upstream	35.4	N/A	N/A	N/A	Eye pain	Foreign body	Eye	h	Eye drops	GH
30	46	3	M	Player	11:20	Upstream	34.1	109	206	19	Vesicle	Burn	Leg	a	Neomycin; Silvadene, local use	GH
31	42	3	M	Player	11:25	Upstream	34.9	N/A	N/A	N/A	A/W	Impact	Right knee	a + b + c	N/A	GH
32	25	4	F	Player	11:30	Upstream	36.6	N/A	N/A	N/A	Eye pain	Foreign body	Eye	h	Eye drops	GH
33	37	4	M	Player	11:30	Upstream	35.1	N/A	N/A	N/A	Eye pain	Conjunctivitis	Eye	h	Sinomin ophthalmic solution 4%, 1 drop	GH

(Continued)

Table 1. (*Continued*)

Case no.	Age (yr)	Triage level	Sex	Identification	Time	Medical station location	Vital signs				Wound type	Mechanism	Body part injured	Wound treatment	Drug medication	Outcome
							BT (°C)	PR (/min)	SBP (mmHg)	DBP (mmHg)						
34	40	4	F	Player	11:40	Upstream	35.2	N/A	N/A	N/A	Headache	N/A	Head	NO	N/A	GH
35	53	4	M	Player	11:40	Upstream	36.7	N/A	N/A	N/A	L/W, A/W	Fall	Left toe	a+b+c	N/A	GH
36	51	4	M	Player	11:40	Upstream	37.4	N/A	N/A	N/A	Eye pain	Conjunctivitis	Eye	h	Sinomin ophthalmic solution 4%, 1 drop	GH
37	44	4	M	Player	11:45	Upstream	N/A	N/A	N/A	N/A	A/W, eye pain	Fall	Leg	h	Sinomin ophthalmic solution 4%, 2 drops	GH
38	29	4	M	Player	11:52	Upstream	36.3	N/A	N/A	N/A	Eye pain	Conjunctivitis	Eye	h	Sinomin ophthalmic solution 4%, 1 drop	GH
39	38	4	M	Player	11:55	Upstream	34.7	N/A	N/A	N/A	A/W	Impact	Right finger	a	N/A	GH
40	47	4	F	Player	12:00	Upstream	35.0	N/A	N/A	N/A	Eye pain	Conjunctivitis	Left eye	h	Sinomin ophthalmic solution 4%, 1 drop	GH
41	26	3	M	Player	12:00	Upstream	N/A	N/A	N/A	N/A	A/W	Fall	Toe	a	N/A	GH
42	60	4	M	Player	12:00	Upstream	34.9	N/A	N/A	N/A	A/W	Impact	Leg	a	N/A	GH
43	27	3	M	Player	12:10	Upstream	N/A	N/A	N/A	N/A	A/W	Impact	Upper limb	a	N/A	GH
44	44	4	F	Player	12:15	Upstream	N/A	N/A	N/A	N/A	A/W	Impact	Chin	a	Silvadene, local use	GH
45	32	4	M	Player	12:15	Upstream	34.9	N/A	N/A	N/A	A/W	Impact	Foot	a+c	N/A	GH
46	32	3	M	Player	12:20	Upstream	33.7	N/A	N/A	N/A	A/W	Fall	Upper limb	a+c	N/A	GH
47	20	4	M	Player	12:20	Upstream	N/A	N/A	N/A	N/A	L/W	Stab	Upper limb	d	N/A	GH
48	9	2	M	Resident	12:20	Upstream	N/A	N/A	N/A	N/A	A/W, nail injury	Fall	Leg	a+b	N/A	GH
49	30	4	M	Player	12:25	Upstream	34.1	N/A	N/A	N/A	A/W	Impact	Foot	a+c	Neomycin	GH
50	27	3	M	Player	12:30	Upstream	36.4	116	124	106	A/W	Impact	Toe	a+b	N/A	GH
51	29	4	M	Player	12:30	Upstream	N/A	N/A	N/A	N/A	A/W, wound pain	Impact	Finger	a	N/A	GH
52	25	4	M	Player	12:30	Upstream	32.6	N/A	N/A	N/A	A/W	Impact	Toe	a	N/A	GH
53	23	3	M	Player	12:32	Upstream	34.0	N/A	N/A	N/A	Convulsion	N/A	Thigh	f	N/A	GH
54	56	4	M	Player	12:35	Upstream	36.6	87	185	122	L/W, A/W	Impact	Face	a+c	Gentamicin cream	GH
55	33	3	F	Player	12:35	Upstream	N/A	N/A	N/A	N/A	Convulsion	N/A	Leg	f	N/A	GH
56	21	2	F	Player	12:40	Upstream	33.4	N/A	N/A	N/A	Chill	Hypothermia	General	i	Ginger tea	GH
57	24	3	F	Player	12:40	Upstream	33.3	N/A	N/A	N/A	A/W	Impact	Right knee	d	N/A	GH
58	36	4	M	Player	12:40	Upstream	N/A	N/A	N/A	N/A	C/W, A/W	Fall	Upper limb	a+c	N/A	GH
59	17	2	F	Player	13:00	Upstream	33.3	N/A	N/A	N/A	Chill	Hypothermia	General	i	Ginger tea	GH
60	29	2	F	Player	13:00	Upstream	34.0	N/A	N/A	N/A	Chill	Hypothermia	General	i	Ginger tea	GH
61	25	2	M	Player	13:00	Upstream	36.3	N/A	N/A	N/A	L/W, A/W	Stab	Upper limb	a+c	N/A	GH
62	33	1	M	Player	13:02	Upstream	34.4	N/A	N/A	N/A	Convulsion	Drowning	General	e	N/A	TTH
63	22	4	M	Player	13:10	Upstream	34.0	N/A	N/A	N/A	L/W	Impact	Right ankle	a+b	N/A	GH

BT=body temperature; PR=pulse rate; SBP=systolic blood pressure; DBP=diastolic blood pressure; M=male; N/A=not available; MO=medication and observation; GH=go home; L/W = laceration wound; a=iodine sterilization; RHT=refer to hospital for tetanus; A/W=abrasion wound; b=adhesive bandage; NO=no treatment; C/W=contusion wound; F=female; h=normal saline irrigation; ROC=refer to ophthalmic clinic; c=immobilization; TTH=transport to hospital; g=elastic bandage; d=ice pack; f=nonsteroidal anti-inflammatory drug; i=rewarming; e=spray nonsteroidal anti-inflammatory drug.

Table 2. *Characteristics of the patient sample (n = 63)*

Variable	*n* (%)
Sex	
Male	49 (78)
Female	14 (22)
Triage	
Level 1	1 (2)
Level 2	7 (11)
Level 3	16 (25)
Level 4	39 (62)
Identification	
Spectator	3 (5)
Player	54 (86)
Medical staff	2 (3)
Non-medical staff	2 (3)
Resident	1 (2)
Other	1 (2)

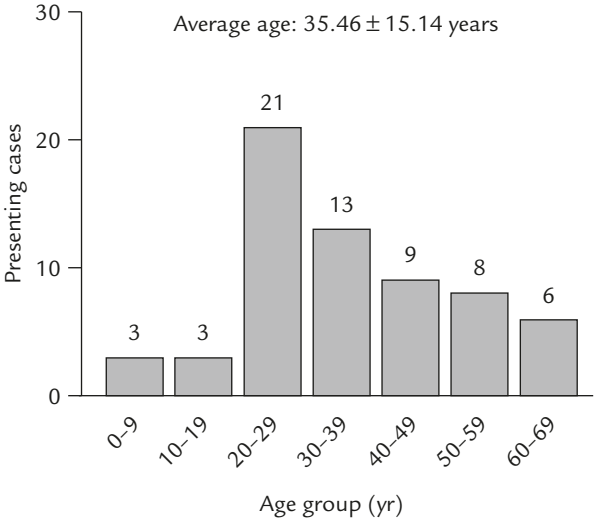


Figure 3. Estimated cases of injury by age group (*n* = 63).

of presentations also increases[3,6,12,13,36–44]. However, the PPR appears to reduce slightly in crowds larger than 1 million. It is important for organizers to evaluate the crowd size closely and predict the possibility of PPR correctly, in order to prepare sufficient first aid and emergency personnel for handling the likely number of patient presentations at a particular MG. In addition, several anecdotal reports and retrospective reviews have suggested that possible danger and increased morbidity result from inaccurate predictions of attendance[45–47]. Different kinds of MGMC have different risks according to the number of patient presentations and the number of patients transported to hospital[33].

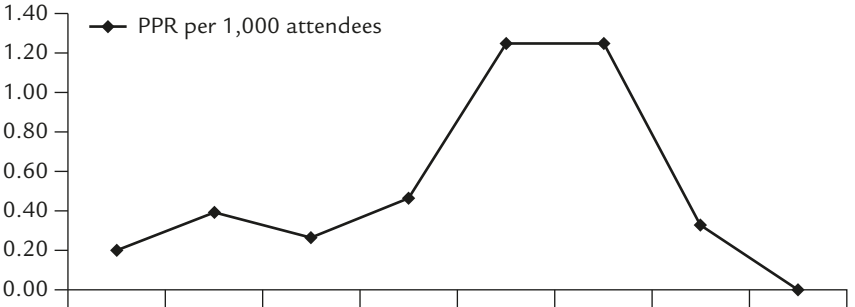
Table 3. *Comparison of the start and upstream medical stations by patient presentation rate (PPR) and medical usage rate (MUR)*

Station	PPR		MUR	
	n (%)	*n* per 1,000 attendees	*n* (%)	*n* per 1,000 attendees
Start	14 (22)	0.92	12 (19)	0.79
Upstream	49 (78)	3.23	47 (75)	3.09

The bounded/focused type of MG is the most common of all four types of MG, up to 92.5%. In this MG, 2.4% of patients will be transported to hospital. PPR at the unbounded/extended type of MG is 6.8%, with 7.7% of patients transported to hospital. PPR at the bounded/extended type of MG is 0.1%, with 33.3% transported to hospital. PPR at the unbounded/focused type of MG is the lowest of all four types of MG, up to 0.4%, with no patients transported to hospital.

It is difficult to provide exact definitions of the event categories for the Sun-Moon Lake long-distance swimming festival. This activity is not clearly held in a restricted area but is bounded by the edge of the lake. However, a specific track is enclosed for participants. Event type is an important MG variable, and there are distinctive aspects inherent in each type. In addition to event type, several other important variables should be considered, including whether the event is indoors or outdoors and whether there is assigned seating[16]. Without shade, outdoor events can lead to exposure, sunburn, and other environment-related injuries[3,12,41,47]. On wet, cold or rainy days, spectators may be exposed at outdoor events, leading to possible hypothermia and the risk of slipping and falling[41]. If any participant fails to complete the course by the cut-off time, they should be removed from the water. The cut-off time will be dependent on water conditions, weather conditions, air temperature, and the length of the swim. Milsten et al.[14] have indicated that on-site medical assistants must do their best to shorten the time taken to reach the patient, facilitate triage and stabilize the patient, and must avoid any delay to initiation of vital treatment. EMS, by establishing fixed, effective procedures for the treatment of mild injuries or illness at MG events, will also reduce the burden on local medical facilities[21,22].

PPRs differ significantly between the categories of bounded/focused and unbounded/extended events. Bounded/focused events have been published with a



Attending time	07:00	08:00	09:00	10:00	11:00	12:00	13:00	14:00
PPR per 1,000 attendees	0.20	0.39	0.26	0.46	1.25	1.25	0.33	0.00
MUR per 1,000 attendees	0.20	0.33	0.13	0.46	1.18	1.25	0.33	0.00

PPR = patient presentation rate; MUR = medical usage rate.

Figure 4. Patient participation rate against time of attendance.

Table 4. *Injury statistics for the patient sample (n = 63)*

Type of wound	*n* (%)
Abrasion	34 (54)
Simple	22 (35)
Complicated	12 (19)
With laceration	8 (13)
With wound pain	3 (5)
With nail injury	1 (2)
Contusion	7 (11)
Simple	5 (8)
Complicated	2 (3)
With eye complaint	1 (2)
With abrasion	1 (2)
Laceration	4 (6)
Eye complaint	8 (13)
Eye pain	6 (10)
Eye vesicle	2 (3)
Convulsion	2 (3)
Abdominal pain	3 (5)
Chill	3 (5)
Headache	1 (2)
Consciousness change	1 (2)

Table 5. *Mechanism of injury of the patient sample (n = 63)*

Mechanism of injury	*n* (%)
Impact	31 (49)
Fall	8 (13)
Conjunctivitis	4 (6)
Stab	4 (6)
Hypothermia	3 (5)
Sprain	1 (2)
Foreign body	2 (3)
Edema	1 (2)
Drowning	1 (2)
Burn	1 (2)
Not available	7 (11)

Table 6. *Body parts injured in the patient sample (n = 63)*

Body part injured	*n* (%)
Leg	16 (25)
Upper limb	10 (16)
Foot	4 (6)
General	4 (6)
Toe	5 (8)
Ankle	2 (3)
Face and chin	2 (3)
Knee and thigh	4 (6)
Finger and palm	3 (5)
Eye	6 (10)
Abdomen	3 (5)
Chest	1 (2)
Head	2 (3)

PPR of 1.264 patients per 1,000 attendees, and patients in this category with a TTHR of 0.03 patients per 1,000 attendees. In general, events included in this category are stadium-based sporting events, including football, concerts and fairs. In contrast, unbounded/extended events have been reported with a PPR of 0.266 per 1,000 attendees, and a TTHR of 0.02 persons transported per 1,000 attendees. These events are usually parades, fun runs, and other races[27].

Environmental factors play an important part in the PPR of MGMC. The heat and humidity at the event studied were the two key issues most likely to influence illness. Hot weather can lead to dehydration and

Table 7. *Records of vital signs in the patient sample (n = 63)*

Vital sign	*n* (%)
Body temperature	
> 38°C (fever)	0 (0)
34–38°C (normal range)	34 (54)
< 34°C (hypothermia)	5 (8)
Not available	24 (38)
Systolic blood pressure (mmHg)	
> 140	5 (8)
90–140	6 (10)
< 90	1 (2)
Not available	51 (81)
Heart rate (/min)	
> 100	7 (11)
60–100	7 (11)
< 60	0 (0)
Not available	49 (78)

Table 8. *Frequency of drug use in the patient sample (n = 63)*

Drug	*n* (%)
Not applicable	47 (75)
Ginger tea	3 (5)
Buscopan	1 (2)
Neomycin	1 (2)
Eye drops	2 (3)
Sinomin ophthalmic solution 4%	5 (8)
Silvadene	1 (2)
Neomycin + Silvadene	1 (2)
Gentamicin cream	1 (2)
Gascon	1 (2)

heat-related illnesses, whereas cold weather can lead to hypothermia and frostbite[3,41,43,46,48]. Arbon et al.[33] reported their highest PPR when the weather was at a peak of 25°C. PPR also increases progressively with humidity in the range of 21% to 81%. There have been many previous case reports on the effects of hot weather on persons at MG events[45,46,49]. There have been numerous case reports of heat-related illness during concerts[19,20,50]. Heat-related illness may explain why more patients were seen during the noon period than at other times in the present study. Cold weather events generally seem to generate lower casualty rates[4,51,52]. Hypothermia will be more likely at events with water (i.e., swim meets) or rain, or where alcohol is used by the participants[3,53].

When events occur at a predetermined location, anticipated attendance can be determined based on previous events; however, prediction of crowd size for one-off events has been chaotic and inaccurate in the past[4,43]. In our study, the numbers of patients was higher than predicted (63 vs. 30). The prediction was based on similar MG events, including the outdoor, bounded, sporting events with no seating (Table 9). This may have been because of specific factors corresponding to the environment, such as swimming-related illness or lake-related injury. These are, to date, not well-recognized causes of patient presentation in this category of events. Humidity has a consistent effect on the number of patient presentations[36]. Eight patients at the Sun-Moon Lake event presented with injuries caused by falls that may have been partly attributable to humidity. The second possible reason for the PPR being higher than predicted in the specific environment of this event may be the increased risk of hypothermia caused by prolonged immersion in the lake.

The total number of spectators attending the event in the research sample was 15,189. The total number of patients evaluated was 63. Of these patients, five required subsequent transportation to hospital for further treatment. The PPR was 4.15 patients per 1,000 attendees at the event. In previous reports, PPRs have varied significantly, with values ranging from 0.14 to 90.0, although most reported events showed a PPR range from 0.5 to 2.0 per 1,000 attendees[27]. The highest PPR has been noted for events such as one-off outdoor rock festivals (26.85 patients per 1,000 attendees), and the lowest rate reported was at an indoor rally event (0 patients per 1,000 attendees). In our study, the actual number of patients was apparently close to that estimated (2 vs. 2.18) from the similar MG events that were bounded with no seating (Table 10). The TTHR in our study was 0.13 per 1,000 attendees. Previously reported TTHRs have ranged between 0.01 and 0.55 per 1,000 attendees.

Events at which individuals are mainly seated, such as large stadium events, generally result in a significantly lower PPR. If spectators are moving, they appear more liable to experience injury. Minor injuries (cuts, abrasions, contusion, sprains) and less severe complaints (e.g., headaches, sunburn, blisters) can account for 77% of the total patient presentations at this kind of moving event. Several conditions can worsen heat-related illnesses, including dehydration, fever, infection, lack of recent heat exposure, insufficient

Table 9. *Prediction of the total number of patient presentations**

Variable	Estimate value (C)	Parameter estimate (b)	Estimate (C) × (b)	Actual
Intercept		–78.184699	–78.184699	
Seats†	0	–31.488567	0	
Bounded‡	1	84.556898	84.556898	
Indoor§	0	42.370240	0	
Outdoor‖	1	81.319501	81.319501	
Sport¶	1	–20.390940	–20.390940	
Humid	81	–0.616134	–49.906854	
Attend	15,189	–0.000456	–6.930288	
AttHumid	81	0.000016	19.684944	
Day-Night#	0	20.067439	0	
Y**			30.148562	63

**From Arbon et al.[33]; † = 1 when the event has a nonmobile population (i.e., attendees are seated), and = 0 when the population is mobile; ‡ = 1 when the event is fenced/bound, and = 0 when the event is unbound; § = 1 when the event is indoors, and = 0 when the event is outdoors; ‖ = 1 when the event is outdoors, and = 0 when the event is indoors; events that are both indoor and outdoor record a 1 for "Indoor" and a 1 for "Outdoor"; ¶ = 1, for all sporting events, and = 0, for all nonsporting events; # = 1 for events which are both day and night, and = 0 for events which are only day or only night; **predicted number of presentations, Y = –78.184699 + (–31.488567 × Seats) + (84.556898 × Bounded) + (42.370240 × Indoor) + (81.319501 × Outdoor) + (–20.390940 × Sport) + (–0.616134 × Humid) + (–0.000456 × Attend) + (0.000016246 × AttHumid) + (20.067439 × Day-Night). Humid = level of humidity (%) expected for the day of the event; Attend = number of persons expected to attend the event that day; AttHumid = result of multiplying the expected humidity by the expected attendance.*

Table 10. *Prediction of the total number of patients transported to hospital for a known number of presentations**

Variable	Estimate value (C)	Parameter estimate (b)	Estimate (C) × (b)	Actual
Intercept		0.0		
TotNum	63	0.010980	0.69174	
Seats†	0	–1.012146	(2)	
Bounded‡	1	1.489817	1.489817	
Y§			2.181557	2

**From Arbon et al.[33]; † = 1, when the event has a non-mobile population (i.e., attendees are seated), and = 0, when the population is mobile; ‡ = 1, when the event is fenced/bound, and = 0, when the event is unbound; §the predicted number transported to hospital for a known number of presentations, Y = 0.0 + (0.010980 × TotNum) + –1.012146 × Seats) + (1.489817 × Bounded). TotNum = number of known presentations.*

training, alcohol abuse, sunburn, lack of sleep, excessive clothing, and diarrhea or vomiting[54].

The lake festival is health-oriented and there are no age limits; however, it is only open to groups. The event is scheduled on a Sunday each year, and takes place either before or after the mid-autumn festival, because the water or air temperature at that time is most suitable. The characteristics of the activity are important to the participants. Although two persons were warned of their health issues, they insisted on continuing the course.

There has never been any discussion about setting up medical stations along the waterfront for this kind of MGs. This may be due to the lack of experience to evaluate the possibility of injury occurring after players enter the water. Immediate help was needed in the case of the individual that was drowning. Significantly, the PPR was three times higher at the endpoint (the upstream station) compared with the departure point (3.23 vs. 0.92 per 1,000, respectively). The highest medical usage rate has been reviewed, especially for outdoor events with mobile spectators, a crowd size of less than 30,000, and for sites with seated patrons[55]. Some authors have found that the medical usage rate can be predicted based on the estimated crowd size[40,56]. It has also been noted that the medical usage rate can be predicted roughly based only on crowd size and the duration of the event[16].

The data suggests that during the Sun-Moon Lake festival, the upstream medical station needs to be the better equipped and staffed of the two stations. The reason for this is not only the higher rate of injuries sustained in this area but also the higher rate of medical resources utilized. Emergency care at events has to base on a good relationship with the regional hospital

responsible for the local emergency service, with an emphasis on the assurance of integrity and quality of medical care, especially in cases such as infection. Safety issues, such as anti-terrorism measures, should be taken into account in all medical measures. It is a major challenge holding an MG activity at a site that lacks local medical resources, such as the Sun-Moon Lake festival. The main problem encountered during the event consisted of a transfer called off by a patient because transportation would take 4 hours, despite the large wound in question.

The type of event will determine the approximate age range of those attending, while location characteristics will determine physical barriers to medical care[12]. Therefore, the setup of provisional surgery outpatient clinics should be considered in order to provide complete treatment in cases of wound infection. On-site treatment with drug applications currently includes iodine, ointment and bandages, but invasive procedures are rarely possible.

Sun-Moon Lake festival also suffers from poor communication links. This is exacerbated by network overload created by large numbers of attendees using their mobile phones simultaneously.

Body temperature during a swimming event is roughly related to the swim duration and speed, yet this could not be evaluated because the time that each participant began was not available to determine the duration in the water or the reasons for low body temperature from the medical history. A case of shock seen at the event was caused by a person swimming too fast, which led to exhaustion. The host of the event should, therefore, emphasize that the event is not intended to be a competition to avoid potential medical problems caused by participants pushing themselves too hard. A further danger of such events is that the use of certain medications, such as anticholinergics, sympathomimetics and neuroleptics, can lead to higher morbidity. Increased temperature (at the time of the event) increases the medical usage rate of these kinds of medications[40].

The majority of the evidence obtained from this study suggests that planners would benefit from using the classification system by Sanders et al.[5] to assist their event planning. Sanders et al. found that seated events are often of shorter duration (< 6 hours) than mobile events (> 1 day)[5]. The duration of an event is a further variable that is important in the determination of PPRs[3–5,7,16,17,37,39,42,43,55,57,58]. Hypothermia can occur in relatively warm water, particularly in weaker swimmers. A cut-off time for the swim should be agreed with the race official/referee prior to the event[21,22].

Recommendations for the Sun-Moon Lake Festival

Based on the data collected in this study, several recommendations can be made to improve the medical care provided at the Sun-Moon Lake festival. Firstly, medical station doctors should be assigned the role of referee. Individuals participating in the swimming activity should be encouraged to consider their own safety with medical stations serving only a first aid function. The suturing of wounds could possibly be performed on-site with the erection of a temporary clinic. The starting area should be equipped with a buffer area to allow swimmers to adapt their body temperature. Boats in the reef area of the upstream part of the lake should be equipped to reduce the likelihood of injury. Swimmers must be encouraged to take part non-competitively to avoid collision, illness or injury caused by excessive speed. The location of a third medical station should be determined in a guideline sheet or plan in order to provide a general medical service. The communication system should establish a communication code number and determine the communication quality in advance. The first aid system needs to include a command center with links to the fire-fighting service.

Conclusion

Multiple interacting variables make the medical requirements of an MG event very difficult to plan. However, establishing the variables that must be considered at all events can make this planning process smoother and more effective. Besides understanding the variables, event medical organizers need to establish some universal planning guidelines[13]. The variables that contribute significantly to the requirements for MGMC include weather and environmental factors, event type and duration, attendance and crowd density, and age. Event type is one of the most important variables that an event planner must consider. Different event types have their own unique issues that must be addressed.

The research reported here has focused on the development of an emergency system according to the

prediction of PPRs and TTHRs at an MG event, such as the Sun-Moon Lake long-distance swimming festival, that takes into account several of the important factors influencing medical requirements. Variations in patient presentations that are influenced by environmental factors should be predicted prior to the event to minimize unexpected events or the lack of required resources. This prediction method can be applied to different venues and types of event using standard definitions of the significant environmental features of the event and venue. Some specific events are characterized by extraordinarily high or low PPRs that fall outside the normal range. The important issue for emergency doctors and activity organizers or sponsors is how to protect the individuals attending an event and improve the rescue and treatment abilities of personnel should accidents occur. The ability to quickly transport injured or ill parties to hospital and to maintain the patient's safety and well-being is paramount. The predictive modeling discussed in this study remains a useful tool for a unique event. Examination of the data from the Sun-Moon Lake festival in previous years can be used to determine the types of injuries, where they occur, their causes, etc. This allows organizers to change, minimize or remove the negative environmental factors, such as heat and humidity to benefit the health and safety of patients and to improve the available medical services. Epidemiologic investigations of the PPR at MGs have provided the foundation for the provision of appropriate and personalized health care services at these events. Nevertheless, research into this topic is still inadequate to support the on-site physician's decisions about the level and extent of health care services at large public events, and this remains an area in need of further research. Any resolutions derived remains to be tested at future MG events.

In future, with the capability of predicting patient presentation provision, the selection of adapted medical facilities and even the sharing of databases with local medical systems or facilities will allow first aid workers or emergency physicians to improve the outcome of patients at the MG events.

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References

1. Ahmed QA, Barbeschi M, Memish ZA. The quest for public health security at Hajj: the WHO guidelines on communicable disease alert and response during mass gatherings. Travel Med Infect Dis 2009; 7: 226–30.
2. Jaslow D, Yancy A 2nd, Milsten A. Mass gathering medical care. National Association of EMS Physicians Standards and Clinical Practice Committee. Prehosp Emerg Care 2000; 4: 359–60.
3. Parrillo SJ. Medical care at mass gatherings: considerations for physician involvement. Prehosp Disaster Med 1995; 10: 273–5.
4. De Lorenzo R. Mass gathering medicine: a review. Prehosp Disaster Med 1997; 12: 68–72.
5. Sanders AB, Criss E, Steckl P, et al. An analysis of medical care at mass gatherings. Ann Emerg Med 1986; 15: 515–9.
6. Hodgetts TJ, Cooke MW. The largest mass gathering: medical coverage for millennium celebrations needs careful planning. BMJ 1999; 318: 957–8.
7. Mears G, Batson D. Mass gatherings. In: Tintinelli JE, Ruiz E, Krome R, eds. Emergency Medicine: A Comprehensive Study Guide, 6th edition. New York: McGraw-Hill, 2004: 21–5.
8. Dutch MJ, Senini LM, Taylor DJ. Mass gathering medicine: the Melbourne 2006 Commonwealth Games experience. Emerg Med Australas 2008; 20: 228–33.
9. Jaslow D, Drake M, Lewis J. Characteristics of state legislation governing medical care at mass gatherings. Prehosp Emerg Care 1999; 3: 316–20.
10. Shah W. Mass gathering medical care: to calculate the Medical Usage Rate of Galway Races. Am J Disaster Med 2010; 5: 61–4.
11. Grange JT, Baumann GW. The California 500: medical care at a NASCAR Winston Cup race event. Ann Emerg Med 1999; 34: 315–8.
12. Leonard RB, Petrilli R, Noji EK, et al. Provision for Emergency Medical Care for Crowds. Dallas: American College of Emergency Physicians, 1990: 1–25.
13. Boatright JR. Emergency medical service—mass gathering action plans. J Emerg Nurs 2004; 30: 253–6.
14. Milsten AM, Maguire BJ, Bissell RA, et al. Mass-gathering medical care: a review of the literature. Prehosp Disaster Med 2002; 17: 151–62.
15. Thompson JM, Savoia G, Powell G, et al. Level of medical care required for mass gatherings: the XV Winter Olympic

Games in Calgary, Canada. Ann Emerg Med 1991; 20: 385–90.
16. Fransaszek J. Medical care at mass gatherings. Ann Emerg Med 1986; 15: 600–1.
17. Michael JA, Barbera JA. Mass gathering medical care: a twenty-five year review. Prehosp Disaster Med 1997; 12: 305–12.
18. Furst IM, Sandor GK. Analysis of a medical tent at the Toronto Caribana Parade. Prehosp Disaster Med 2002; 6: 199–203.
19. Dress JM, Horton EH, Florida R. Music, mud and medicine. Woodstock '94: a maniacal, musical mass-casualty incident. Emerg Med Serv 1995; 24: 21, 30–2.
20. Florida R, Goldfarb Z. Woodstock '94: peace, music, and EMS. JEMS 1994; 19: 45–8.
21. McGuire LC, Bell AZ. Developing an enhanced minor injury unit for support of urban festivities. Eur J Emerg Med 2001; 8: 193–7.
22. Boyle MF, De Lorenzo RA, Garrison R. Physician integration into mass gathering medical care: the United States Air Show. Prehosp Disaster Med 1993; 8: 165–8.
23. Hnatow DA, Gordon DJ. Medical planning for mass gatherings: a retrospective review of the San Antonio Papal Mass. Prehosp Disaster Med 1991; 6: 443–50.
24. Zhang YP, Wang ZJ, Chen XY. Public health response to mass gathering. Zhonghua Liu Xing Bing Xue Za Zhi 2008; 29: 737–9. [In Chinese]
25. Wang SJ, Yoon HD. Medical aspects of unexpected multiple mass gatherings in the streets during 2002 FIFA World Cup soccer game in Korea. Prehosp Disaster Med 2002; 17 (Suppl 2): S42. [Abstract]
26. Chang WH, Huang CH, Chien DK, et al. Factors analysis of cardiopulmonary resuscitation outcomes in the elderly in Taiwan. Int J Gerontol 2009; 3: 16–25.
27. Bowdish GE, Cordell WH, Bock HC, et al. Using regression analysis to predict emergency patient volume at the Indianapolis 500 mile race. Ann Emerg Med 1992; 21: 1200–3.
28. Feldman MJ, Lukins JL, Verbeek PR, et al. Use of treat-and-release medical directives for paramedics at a mass gathering. Prehosp Emerg Care 2005; 9: 213–7.
29. Weaver WD, Sutherland K, Wirkus MJ, et al. Emergency medical care requirements for large public assemblies and a new strategy for managing cardiac arrest in this setting. Ann Emerg Med 1989; 18: 155–60.
30. Raphael B. Crowds and other collectives: complexities of human behaviors in mass emergencies. Psychiatry 2005; 68: 115–20.
31. Zielinski A. Enhanced surveillance at mass gatherings. Przegl Epidemiol 2009; 63: 477–85.
32. Zeitz KM, Zeitz CJ, Arbon P. Forecasting medical workloads at mass gathering events: predictive models as an adjunct to retrospective review. Prehosp Disaster Med 2005; 20: 164–8.
33. Arbon P, Bridgewater FHG, Smith C. Mass gathering medicine: a predictive model for patient presentation rates. Prehosp Disaster Med 2001; 16: 150–8.
34. Morimura N, Katsumi A, Koido Y, et al. Analysis of patient load data from the 2002 FIFA World Cup Korea/Japan. Prehosp Disaster Med 2004; 19: 278–84.
35. Wassertheil J, Keane G, Fisher N, et al. Cardiac arrest outcomes at the Melbourne Cricket Ground and Shrine of Remembrance using a tiered response strategy—a forerunner to public access defibrillation. Resuscitation 2000; 44: 97–104.
36. Richards R, Richards D, Whittaker R. Method of predicting the number of casualties in the Sydney City-to-Surf fun runs. Med J Aust 1984; 141: 805–8.
37. Green GB, Burnham G. Health care at mass gatherings. JAMA 1998; 279: 1485–6.
38. Nordberg M. EMS and mass gatherings. Emerg Med Serv 1990; 19: 46–51, 54–6, 91.
39. Osler DC, Shapiro F, Shapiro S. Medical services at outdoor music festivals: risks and recommendations. Clin Pediatr (Phila) 1975; 14: 390–5.
40. Thackway S, Churches T, Fizzell J, et al. Should cities hosting mass gatherings invest in public health surveillance and planning? Reflections from a decade of mass gatherings in Sydney, Australia. BMC Public Health 2009; 9: 324.
41. Nardi R, Bettini M, Bozzoli C, et al. Emergency medical services in mass gatherings: the experience of the Formula 1 Grand Prix 'San Marino' in Imola. Eur J Emerg Med 1997; 4: 217–23.
42. Sexton PA, Burns RS, Lerner SE. Sunshine '75: rock medicine inside Diamond Head. Hawaii Med J 1975; 34: 271–5.
43. Leonard RB. Medical support for mass gatherings. Emerg Med Clin North Am 1996; 14: 383–97.
44. Khan K, Freifeld CC, Wang J, et al. Preparing for infectious disease threats at mass gatherings: the case of the Vancouver 2010 Olympic Winter Games. CMAJ 2010; 182: 579–83.
45. Paul HM. Mass casualty: Pope's Denver visit causes mega MCI (mass casualty incident). JEMS 1993; 18: 64–68, 72–75.
46. Schulte D, Meade DM. The papal chase. The Pope's visit: a "mass" gathering. Emerg Med Serv 1993; 22: 46–9, 65–75, 79.
47. Chambers J, Guly H. The impact of a music festival on local health services. Health Trends 1991; 23: 122–3.
48. Whipkey RR, Paris PM, Stewart RD. Emergency care for mass gatherings: proper planning to improve outcome. Postgrad Med 1984; 76: 44, 46–48, 51, 54.
49. Geller RJ, Lopez GP. Poison center planning for mass gatherings: the Georgia Poison Center experience with

the 1996 Centennial Olympic Games. J Toxicol Clin Toxicol 1999; 37: 315–9.
50. Burdick TE. Wilderness event medicine: planning for mass gatherings in remote areas. Travel Med Infect Dis 2005; 3: 249–58.
51. Eadie JL. Health and safety at the 1980 Winter Olympics, Lake Placid, New York. J Environ Health 1981; 43: 178–87.
52. Reardon TF. EMS and disaster planning for the Winter Olympics. Emerg Med Serv 1979; 8: 88–90, 92, 199.
53. Pons PT, Holland B, Alfrey E, et al. An advanced emergency medical care system at National Football League games. Ann Emerg Med 1980; 9: 203–6.
54. James SH, Calendrillo B, Schnoll SH. Medical and toxicological aspects of the Watkins Glen Rock Concert. J Forensic Sci 1975; 20: 71–82.
55. Baker WM, Simone B, Niemann JT, et al. Special event medical care: the 1984 Los Angeles Summer Olympic experience. Ann Emerg Med. 1986; 15: 185–90.
56. Friedman LJ, Rodi SW, Kruegur MA, et al. Medical care at the California AIDS Ride 3: experiences in event medicine. Ann Emerg Med 1998; 31: 219–23.
57. Ounanian LL, Salinas C, Shear CL, et al. Medical care at the 1982 US Festival. Ann Emerg Med 1986; 15: 520–7.
58. Schlicht J, Mitcheson M, Henry M. Medical aspects of large outdoor festivals. Lancet 1972; 1: 948–52.