An Organized Medical Response for the Vancouver International Marathon (2006–2011): When the Rubber Hits the Road

Sheila A. Turris, RN, PhD[1]; Adam Lund, BSc, MD, MDE, FRCPC[2]; Justin Mui, BSc[3]; Peter Wang, BSc[4]; Kerrie Lewis, LPN, EMR[5]; and Samuel J. Gutman, MD, CCFP(EM)[2]

Abstract
Objective: We described an organized, on-site medical response for a large-scale urban marathon event and documented illness/injury rates as well as ambulance transfer rates at the Vancouver International Marathon (VIM). Methods: Case-series report of medical encounters was documented prospectively over a 6-yr period at the VIM. The planning and organization of the on-site medical response is the main focus of this report. Results: A total of 67,402 runners participated in the VIM from 2006 to 2011. Over the 6-yr period, 2,986 patient encounters were documented. The patient presentation rate for the series was 45/1,000, the ambulance transfer rate was 0.09–0.58/1,000, and the medical transfer rate was 0.37–1.09/1,000. Conclusion: A coordinated on-site medical team covering the entire event site and race route was deployed to reduce the severity of illness and injury at a long-distance running event.

Introduction

The Vancouver International Marathon (VIM) is held annually on the first Sunday of May in Vancouver, British Columbia (BC), Canada. Attracting >10,000 participants from dozens of countries, the race attracts both elite and recreational runners and is a qualifying event for both the Boston and New York Marathons. As with many metropolitan marathons, multiple distances were available to participants, including a full marathon, a half marathon, an 8-km run, and a kids' 1-km "Marafun."

[1]Schools of Nursing, University of British Columbia, University of Victoria, British Columbia, Canada; [2]Department of Emergency Medicine, University of British Columbia, Vancouver, British Columbia, Canada; [3]Faculty of Medicine, University of British Columbia, Vancouver, British Columbia, Canada; [4]Undergraduate Student, University of British Columbia, Canada; [5]Mass Gathering Medicine Interest Group, Department of Emergency Medicine, University of British Columbia, Canada

Address for correspondence: Sheila A. Turris, RN, PhD, Vancouver Coastal Health, 6th Floor, 132 West Esplanade, North Vancouver, British Columbia V7M 1A2, Canada; E-mail: Sheila.Turris@vch.ca.

1537-890X/1303/147–154
Current Sports Medicine Reports

A literature search conducted on MEDLINE, PubMed, and Web of Science yielded several reports pertaining to long-distance running published in the past two decades. During any marathon, roughly 2%–8% of participants (range, 0.02–0.08) will experience illness or sustain injuries requiring medical attention (5,19). The majority of the presenting illnesses or injuries are not severe and require minimal examination and treatment; however, a small number of participants will present with potentially serious chief complaints (21). These individuals require urgent advanced assessment to stratify risk of serious illness. On-site facilities, personnel, and care may enable patients' conditions to improve enough to obviate the need for ambulance transfers, decreasing impact on the prehospital system and the local emergency departments (17,19,24).

Fatalities have been documented at a rate of 0.8 per 100,000 participants (18). In 2012, for a sample of 10.9 million participants, 0.54 per 100,000 experienced cardiac arrest, the majority of which were related to cardiac disease (9). At the 2009 Detroit Marathon, three men collapsed and experienced cardiac-related events (10). In 2011, there were two reported marathon deaths within Canada, both the result of marathon-associated cardiac arrest. The first occurred during the Montreal Marathon when a 32-yr-old male participant went into cardiac arrest approximately 1 km from the finish line (3). The second runner to experience a cardiac-related event was a 27-yr-old male participant who collapsed near the midpoint of a half marathon in Toronto (16). Similarly during the 10-km Sun Run held annually in Vancouver, BC, a 31-yr-old female participant collapsed in cardiac arrest at the finish line (12). Fortunately she received rapid assessment and defibrillation on site. Autopsy studies of deaths during participation in endurance running events are attributed most commonly to undiagnosed atherosclerosis, electrolyte imbalance, coronary anomalies, or heat stroke (18). Sanchez *et al.* (21) provide an excellent review on this topic.

Seminal work done in the study of marathon injuries has shaped an understanding of many of the major risks faced by marathon participants and has led event directors to implement changes such as earlier start times and route closures. By effectively reducing injury rates and, therefore, demand for medical services, such operational changes remain essential in planning and implementing medical support for marathons (Table 1) (5,19).

A well-organized on-site medical team with the capacity to triage and provide care during an event can 1) improve safety for both spectators and participants; 2) mitigate risk and liability for event organizers; and 3) reduce the impact and burden on local emergency medical services by enabling safe disposition of patients back to the event after medical encounters or onward to definitive care in reduced numbers (4).

Although there is consensus regarding the factors that increase risk for event participants, the precise composition and strategic placement of medical teams as well as the most efficient and reliable approach to communication infrastructure continue to be debated among marathon planners. On-site triaging, relocating teams during a given event, and strategic placement of medical stations in order to accommodate surges in patient presentation better are endorsed (4,17,20). These articles offer a foundation for event planners; however, they address neither the unique risks that are specific to each race (*e.g.*, the range of possible weather, course conditions, runner experience, and training levels) nor the unique emergency service infrastructure.

In the context of the VIM, we 1) describe event variables thought to influence injury profiles, such as course layout, topography, and weather conditions; 2) describe an organized on-site medical response for a large-scale, urban, cool marathon; 3) explore logistical and management considerations in detail; and 4) document patient presentation rates (PPRs), ambulance transfer rates (ATRs), and medical transfer rates (MTRs) over a 6-yr period (Table 2).

Methods

Event-Related Data

Event data were gathered on site via direct observation and correspondence with event organizers and included the number of participants and course boundaries and conditions. Meteorological data were gathered retrospectively from the

Table 1.
Variables influencing patient presentation rates at marathon events.

Variable	Effect on PPR	Methods to Mitigate Effect on PPR	References
Weather condition	↑ Hot or humid	Avoid scheduling events during hot, humid, or very cold months.	(1,11,17)
	↑ ↓Cold, rainy, or windy	Implement earlier start times to attain cooler racing environments. Ensure adequate supply and strategic placement of fluid stations. Use wet bulb globe temperature index as a measure of thermal injury risk. Inform participants if there is a risk of heat illness. Consider postponing event.	(4,8,12,13)
Running distance	↑ With increased distances	Consider addition of half-marathon distance to event.	(5)
Course/locale complexity	↑	Maintain adequate traffic and crowd control. Minimize exposure to geographical dangers.	(5,11)
Running experience	↑ With less experience ↓ With more experience	Encourage participants to partake in training programs. Training distances $<40\ km \cdot wk^{-1}$ and regular interval training are strong protective factors for lower extremity injuries.	(17,22,26)
Runner education	↓ With educated runners	Advise participants that adequate fluid consumption before the race can reduce risk of heat illness; however, excessive fluid consumption during endurance events may lead to hyponatremia. Advise participants not to run faster than their cardiorespiratory fitness warrants.	(1,2,8)

Table 2.
Definition of terms.

Abbreviation	Definition[a]
PPR — patient presentation rate	The number of patients attended to on site
ATR — ambulance transfer rate	The number of patients transferred by ambulance off site for medical treatment
MTR — medical transfer rate	The number of patients transferred by any means (*i.e.*, ambulance, private vehicle, taxi, etc.) by the medical team for further investigation and/or management

[a] All rates are per 1,000 participants (all events).

Meteorological Service of Canada (6). Detailed descriptions of medical team members (stratified by health profession), equipment, protocols, advanced medical capacity, and narrative description of initial and dynamic personnel deployment were collected.

Patient Encounters

The Mass Gathering Medicine (MGM) Online Registry Project (the Registry) was initiated to gather data that would inform an understanding of the variables impacting attendees and participants at a variety of diverse events, facilitating the development of evidence-based recommendations for mass participation (MP) and mass gathering (MG) events. The Registry enables prospective data collection, facilitating scholarly analysis, hypothesis generation, and testing (13), and has been used to collect data at the VIM since 2010; data prior to 2010 were entered retrospectively.

Patient encounters were documented prospectively using one of two standardized forms: minor treatment logs (MTL) for dispensary requests (*i.e.*, bandages, water, ibuprofen, etc.) or patient encounter forms (PEF) (*i.e.*, collapse, chest pain, knee pain, etc.) (available from: http://ubcmgm.ca/registry/) (15). Given the lack of a consistent and specific triage system applicable to MG and MP events in the existing literature, a five-category triage system was developed and piloted in 2010 (25). Analysis of the reliability and validity of this scale is in progress.

Completed MTLs, PEFs, and event-related data were entered into the registry. Patient data were de-indentified prior to analysis. Data were abstracted according to specific variables of interest including time of encounter, sex, patient acuity, chief concern as stated (*e.g.*, "my knee hurts"), systems classification of chief concern (*e.g.*, dermatological, cardiac, etc.), vital signs, treatments provided (*e.g.*, massage, physiological, oral, and/or parenteral medications, etc.), discharge instructions, and discharge diagnoses (as per *International Classification of Diseases*, *10th Revision*, codes).

Communication Plan With Redundancies

A detailed and comprehensive medical communication plan and network was established. A medical team communication coordinator (CC) and a dispatcher allowed in-person interactions between the event operations team, medical dispatcher, and the BC Ambulance Special Operations CC. This system enabled tracking and follow-up for all calls and information sharing to coordinate responses, avoiding redundant responses.

Medical teams were linked by a radio network in addition to mobile phones for confidential communication or as a backup in case of radio failure. A network of volunteer amateur radio operators also was engaged around the course as another redundancy in case of technical failure or disaster, serving also as additional spotters on course. In 2010 and 2011, as part of an ongoing study to assess alternate communication strategies, BlackBerry™ handheld devices were incorporated into the communication plan to permit text-based communications between key team members operating in areas of high ambient noise, such as the finish line (14). These devices also allowed the CC to track the location of mobile team members via GPS and cellular triangulation.

Multidisciplinary Team Deployment

Geographically the medical team was divided between "on-course" and "finish line" teams. Nine on-course teams were stationed in tents or temporary structures with two to five basic first aid providers and at least one experienced advanced first aider or registered nurse based on patient volumes at these stations in previous years. Earlier stations were staffed more lightly, and team members in the first three aid stations could be redeployed after the "sweep" of the last runners past their station. In addition, bike teams were utilized to respond to patients between stations and additional bike paramedic teams enabled rapid response to locations where vehicle access was limited, such as along the waterfront portions of the course.

Medical Infrastructure Deployment

Positioned adjacent to the water or fluid stations along the marathon course, each station was situated typically in a 10 × 10 ft tent and equipped with an automatic external defibrillator, basic life support, and first aid supplies.

Ethics

Ethics approval was obtained prior to the initiation of the registry and includes approval for retrospective data entry. The ethics board waived the requirement for written informed consent from individual patients.

Results

Context of the Event

In the 6-yr period of the current study, between 10,402 and 12,503 runners participated annually in VIM races. The course route was stable. The spectator crowd was mobile and predominately at a low density, aside from the finish area, which had significant density and access and egress constraints. The maximum race temperature ranged from 11°C to 16°C. A range of weather conditions was observed (Table 3). Because the weather for each year was cool and damp, the wet bulb globe temperature (*i.e.*, a measure of heat stress) was not calculated.

The main medical tent evolved from 2006 to 2011, varying from two small tents (30 × 30 ft and 40 × 40 ft in earlier years) to a single larger tent (40 × 60 ft) in 2010 and

Table 3.
Attendance, race day temperatures, and weather conditions at the VIM (half and full) from 2006 to 2011.

	2006	2007	2008	2009	2010	2011
Registered participants	12,503	10,651	10,402	10,709	11,159	11,978
Minimum race day temperature (°C)	7.7	9.3	6.0	6.2	6.4	4.3
Maximum race day temperature (°C)	15.7	10.9	13.9	15.4	12.4	15.3
Mean race day temperature (°C)	11.7	10.1	10.0	10.8	9.4	9.8
Weather conditions	Rainy	Rainy	Cloudy	Cloudy	Rainy	Clear

Source for number of participants: VIM Society, 2006–2012.

2011. In the former case, one tent was located near the finish line and focused on the treatment of acute injuries and complaints. The second subacute tent was located in an area 500 m beyond the finish area. In 2011, the single-tent setup contained 15 cots, 3 resuscitation beds, 5 massage and chiropractic tables, and a chair area with 20 chairs for minor treatments.

Anecdotally each year, the majority of serious illnesses and injuries were assessed and treated at the finish line with the on-course station providing predominantly medical dispensary care. Those who collapse at the finish line and other distressed finishers were transported rapidly to the main medical tent located 50–250 m adjacent to the finish line (varied in placement year to year) by a wheelchair.

Patient Presentations

A total of 2,986 patient encounters were documented over a period of 6 yr for a mean of 497 encounters per year (range, 412–572) (Table 4). Start time for the marathon was always early morning. Anecdotally each year, patient presentations peaked for 1 h roughly 2.5 h after the start of the race and the majority of encounters occurred between 2.5 and 4.5 h after the start of the race.

PPR varied each year, with the lowest PPR observed in 2011 at 36.32 and the highest observed in 2007 at 50.42. Whenever possible, patients were treated on site and discharged. A total of 36 patients were transported off site for medical treatment, 23 of whom were transported using ambulances, with the remainder being transported by private means. ATR in the 6-yr period ranged from 0.09 to 0.58; the MTR, which included all ambulance transports plus all other transports for medical purposes, was between 0.10 and 1.09. There were no reported deaths or sudden cardiac arrests. The overwhelming majority of encounters required only dispensary services and/or minimal first aid from a health care provider.

Patient encounters were categorized according to chief complaint. Musculoskeletal (MSK) complaints were nearly always the most prevalent, followed by dermatological complaints and dispensary requests (*e.g.*, medication and ice, respectively). Together these three categories encompassed over 80% of all medical encounters in each of the 6 yr studied. Less common complaints were documented also, including neurological, cardiovascular, respiratory, gastrointestinal, and environmental exposure. Cold-related illness increased markedly in years 2006, 2007, and 2010 and coincided with cool temperatures and precipitation.

Discussion

PPR and MTR at the VIM

The illness and injury rates over the course of our study demonstrate stability. Our specified approach to medical support in the VIM could be applied to marathons of a similar size with similar climate and topography. Given sufficient similarity between marathons, registration numbers could be used to predict PPR accurately and thus allow for more efficient and effective medical planning. This multiyear analysis validates the approach by some MGM authors who show that retrospective data from the same event are highly predictive of PPR at subsequent events (7,23,27).

As previously discussed, fatalities during marathons are reported at a rate of 0.8/100,000. During the 6 yr of this study, for roughly 67,402 participants, there were no sudden cardiac arrests or fatalities reported during the race. This is in keeping with reported fatality rates (18).

Table 4.
Attendance, PPR, ATR, and MTR per 1,000 at the VIM, 2006–2011.

	2006	2007	2008	2009	2010	2011
Participants	12,503	10,651	10,402	10,709	11,159	11,978
Total patients	572	537	499	531	412	435
Ambulance transports	4	6	1	4	1	7
Other medical transports	1	2	0	0	4	6
PPR	45.75	50.42	47.97	49.58	36.92	36.32
ATR	0.32	0.56	0.10	0.37	0.09	0.58
MTR	0.40	0.75	0.10	0.37	0.45	1.09

Table 5.
Comparison of annual PPR and MTR at marathon events across North America (2–4,6).

Event	Twin Cities (1983–1994)	Grandma's (1990–1995)	Baltimore (2001)	Baltimore (2002–2005)	Vancouver International (2006–2011)
Mean no. of participants	6,393	7,183	11,000	8,425	11,233
Mean no. of patients	122	308	251	286	497
Mean PPR	19.08	45.88	22.82	33.95	44.49
Mean MTR	0.35	—	1.55	0.47	0.53

PPR and MTR Compared With Those at Similar Events

The mean PPR and MTR observed over the 6-yr period were 44.49 and 0.53, respectively, which are consistent with those of previous studies and fell within the upper and lower limits reported elsewhere (5,19). A direct comparison of the VIM medical teams with the 2001 Baltimore medical team (17), the team with the highest reported MTR, revealed several differences (Table 5). Specifically the number of personnel qualified to provide medical care and the diversity of skill sets available were greater at the VIM. The range of qualified personnel at the VIM *may have* allowed more comprehensive patient care and helped improve patient management, particularly during surges when the medical team may become overwhelmed. In addition to differences in personnel, the moderate climate experienced by Vancouver runners also may have reduced the number of life-threatening conditions such as hyperthermia.

When interpreting Table 6, extreme caution should be used in drawing conclusions about the varying rates of patient presentations. There is currently no national or international agreement regarding the types of data, the case categorizations, or the analysis of data that should be undertaken. As a result, no valid conclusions can be drawn at this time. For example, consider that in some cases, researchers presented transfers as "emergency room transfers" (19) or "transfers to hospital" (24). Because the VIM MTR includes transfers for *any* medical treatment including both local clinics and the emergency room, this may inflate the VIM MTR. Table 6 is included for the information of the reader only and is meant to generate discussion rather than to serve as a definitive summary of work done to date. Comparing marathons that take place in different climates, at different times of year, and with different degrees of course difficulty may result in erroneous conclusions.

Types of Illnesses and Injuries at VIM Compared With Those at Similar Events

In 2008, Nguyen *et al.* (17) examined injury patterns at a metropolitan multievent marathon consisting of the 3 events: a 5-km run, a standard marathon, and a 4-person marathon relay. Most injuries sustained by runners were minor, and the majority of the presenting runners have not run a marathon previously. The most common chief complaints were medication requests (26%), followed by MSK injuries (18%), dehydration (14%), and cutaneous injuries (11%). Other medical complaints such as dizziness, bandage requests, gastrointestinal complaints, headaches, abdominal pain, and chest pain were reported also but at significantly reduced rates. Of the 11,000 entrants who competed in the events, 251 sought medical attention. The reported PPR and MTR were 22.8 and 1.5 per 1,000 participants, respectively (17).

Previous reports have shown consistently that the large majority of injuries and illnesses sustained by marathon participants are minor and require minimal medical treatment (19,24,26). The results from the current study are consistent with this observation, with 80% of patient concerns related to MSK, dermatology, or dispensary requests.

Variables Influencing Illness and Injury Rates at VIM Compared With Those at Similar Events

The impact of weather on illness and injury rates at marathons has been highlighted in numerous studies. Humidity, wind, and temperatures at either extreme all have been implicated as factors causing increased injury rates among runners (1,5,19). The current study highlights the effects of precipitation on runner injury rates. For the years in which rain was observed (2006, 2007, and 2010), the number of reported complaints of cold-related illness, both mild and severe, increased when rain was present. The damp conditions likely increased convective cooling, leading to a greater number of hypothermic complaints. This information provides a baseline for future planning because injury and illness rates are affected by both local factors and weather conditions, causing the PPR to vary each year (*e.g.*, PPR of 36.32–50.42). New medical teams must consider these factors and others unique to their locale, drawing on existing accounts. For the VIM, this meant having blow-dryers, wool blankets, hot packs, hot oral fluids, and foil blankets available for use by large numbers of participants.

The VIM Legacy

The VIM has been in existence for more than 40 yr. As an annual legacy event, it has been allowed to grow in size without a great deal of oversight by any government or licensing body and without a requirement for an integrated responsive plan to address everything from medical needs and disaster planning to traffic management and public safety. Addressing these issues is made more difficult by the fact that, generally speaking, there is a 2- to 3-yr cycle in Vancouver during which the same individual or individuals are responsible for race planning and, after that, someone new takes on the role. Without planning for succession or mentorship in place, there is neither a formal handover nor a provision for reporting on the race during any given year. In effect, there is no provision for reporting forward into the next year so that problems in the previous year can be addressed in subsequent years (personal communication, Mr. Jordan Myers).

Table 6.
Medical team members providing pre-hospital care at the VIM from 2006 to 2011.

Health Care Provider		2006	2007	2008	2009	2010	2011
Physician	Emergency physician	4	2	2	3	1	3
	General practitioner	2	0	2	1	5	3
	Resident	3	1	3	7	2	1
	Medical student	1	9	3	4	N/A	12
Subtotal		10	14	10	15	8	21
Nurse	Nurse practitioner	0	0	0	0	1	0
	Registered nurse	16	18	18	23	29	19
	Licensed practical nurse	2	1	0	0	2	2
	Nursing student	11	4	1	1	4	7
Subtotal		29	23	19	24	36	28
Prehospital care[a]	Basic life support paramedic	1	3	2	1	0	4
	Emergency medical responder	2	2	2	8	12	7
	First aid provider	37	31	17	19	32	29
	Firefighter				10	16	0
Subtotal		40	36	21	38	60	46
MSK specialists	Podiatrist	0	2	0	0	0	0
	Chiropractor	2	3	1	3	12	7
	Massage therapist	0	2	0	1	1	1
	Physiotherapist	0	0	1	2	0	1
	Physiotherapy student	0	0	0	0	0	11
	Acupuncturist	1	0	0	0	0	0
Subtotal		3	7	2	6	13	20
Administration	Operations team	1	1	1	2	4	3
	Logistics	0	0	1	0	1	2
	Dispatch	0	1	1	1	2	2
Subtotal		1	2	3	3	7	7
Other	Pharmacist	0	0	0	0	1	1
	Naturopathic medicine student	0	0	0	0	0	2
	Volunteer catcher	15	17	19	10	8	7
	Researcher	0	0	0	0	2	1
	Clinical support from Phillips™[b]	0	0	0	0	0	3
Subtotal		15	17	19	10	11	12
Overall total[c]		98	99	74	96	135	134

Vancouver Fire and Rescue Services did not participate prior to 2009.

All medical team members served as volunteers aside from Rockdoc-contracted operations team members and BC Ambulance Special Operations.

[a] This estimate does not include BC Ambulance Special Operations personnel who did not report directly to the medical director for the event.

[b] Phillips staff supported clinicians to use the Phillips cardiac monitor/defibrillator during the event by providing orientation to the device and standby assistance when the device was utilized.

[c] The increase in team size for 2010 and 2011 was due to improved volunteer recruitment and a high rate of returning volunteers (personal communication, Dr. Samuel Gutman).

N/A, no statistics for BC Ambulance Special Operations.

In 2006, a medical service provider was hired to develop a safety plan and to provide on-site medical services for the race. In part, this occurred because in 2005, participant registration and number of injuries had been higher than usual. The 911 system for Vancouver was overwhelmed when there were 22 calls placed in a short period, all for race-related illnesses and injuries (personal communication, Mr. Jordan Myers March 2, 2014).

Several themes emerge when considering the evolution of the VIM medical and operation plan during the study years. First the *communication plan* for the VIM has continued to evolve. Originally, there was no way for operations, paramedics, fire services, first responders, and finish line medical services to communicate with each other. A communication hub, connecting all relevant services, has been in existence since 2009 in various forms, and this has streamlined the response for medical emergencies, allowing the dispatch of the appropriate level of provider and the appropriate type of transport vehicle to the scene. There is now a dedicated medical channel and an integrated dispatch, allowing incoming calls to be triaged according to whether a call is related primarily to operations (*e.g.*, traffic issue, access to water supplies, etc.) or emergency services (*e.g.*, fire, on-site medical team, ambulance services).

Second the *placement of medical services* also has evolved. In the past, medical coverage for the VIM was sited primarily at the finish line. Beginning with the introduction of a contracted medical service provider in 2006, the placement and number of aid stations have continued to evolve over time. Originally there were no aid stations for the VIM, as in the '70s and early '80s when the race was confined to Stanley Park and attracted primarily "seasoned runners." Medical care was provided via volunteer cyclists on the course. Over time, as the race demographic changed, aid stations (9–12) were placed at irregular intervals along the course in areas not contested by local inhabitants or businesses. For the new course (2012), there are 25 aid stations placed as mile markers.

Third *participant and volunteer safety* has been considered carefully. The city and park originally had a 4-h cutoff for use of the streets, which then expanded to 6 h and then 10 h. In effect, there was no "end" to the race. The finish line remained open, and the course did not close until the last participant completed the race. On one occasion, the course was open for 14.5 h (2007). To protect participants and volunteers, the course now closes 8 h after the start of the race.

Fourth, *operations and health services have been streamlined*. This has occurred in several ways. For example, sweep vehicles on the course were driven originally by lay volunteers (*i.e.*, no medical or first aid training). During the study years, the sweep vehicles evolved to become response vehicles for nonemergent illness and injury-related calls and now are driven by first responders who have first aid training. Similarly BC Ambulance Special Operations paramedic and 911 services now are integrated fully with the finish line medical team, preventing unnecessary transfers to hospital.

As eluded at the beginning of this section, no formal records exist with regard to the VIM. The information in this section is drawn from an interview with Mr. Jordan Myers, a senior event manager with 7 yr of experience in producing the VIM.

Composition and Placement of Medical Resources

The size of the medical team increased in 2010 and 2011 due to more successful volunteer recruitment (Table 5). We judged the size of the team to be adequate, even in the context of surge capacity, because no patients waited at triage or to be assessed by a clinical decision maker (*i.e.*, physician or nurse practitioner) at any time during the event. Time to be seen by a nurse was <5 min and by a physician or decision maker, <10 min.

Organization of Medical Services

Medical service provider

The planning and provision of medical services were the responsibility of the medical director, an emergency medicine physician. Beginning in 2006, a commercial provider of event medical services supplied the equipment and operation components of the on-site event medical services. A multidisciplinary team of volunteer health care providers was recruited annually to provide services ranging from basic first aid through to advanced cardiac life support. Professional ambulance services also were contracted on site each year, employing ambulances, bike squads, and stretcher-enabled all-terrain vehicles (Gators).

Staff recruitment and orientation

Annually all volunteers received an event manual detailing the site plan, medical services organization, and communication plan 7–10 d in advance of the event. A minority of members of the multidisciplinary team (Table 6) attended a 2-h orientation prior to the event. All staff attended a 1-h on-site orientation on the morning of the event. This orientation covered common clinical scenarios associated with running events (*e.g.*, exercise-associated collapse), simulated cases, equipment seek and find, and identification of the communication and clinical leads for the main medical tent.

Marathon course

The course was stable over the 6 yr spanned by this report. The course changed substantially in 2012 and 2013, and therefore data are not included in this series.

Strategic placement of medical stations along the course served to maximize the delivery of health care at suspected surge points. As highlighted by Tang *et al.*, (24) only 4% of injured runners were treated at the medical stations during the first 13.5 km over the 4-yr period evaluated at the Baltimore Marathon. Although the existence of these medical stations remains paramount to the medical integrity of the race, medical resources at these stations should be allocated accordingly. A smaller medical team with mobile capabilities for redeployment later in the race appears to be the best choice for these early stations.

Limitations

Limitations of the current study relate to the challenges of capturing complete and accurate patient data. The research team was unable to capture a breakdown of patients by event type (*e.g.*, half marathon vs full marathon). Therefore the population of the present event may differ substantially from reports *vis-à-vis* other marathons, although multi-distance events are common. In addition, VIM events are open to the public, so the number of spectators is unknown. Despite anecdotal evidence suggesting that the number of spectators treated represented only a fraction of the total patient encounters, it is plausible that stated values for PPR, MTR, and ATR are *inflated*, as they were determined based on the total number of registered athletes, volunteers, and administrative staff, excluding spectators. This limitation also was noted in a recent study focusing on MP events (7). On the other hand, patients who were treated and released but required subsequent medical attention at a medical clinic or the local hospital following the closure of the event were not accounted for. In addition, as previously noted by Satterthwaite *et al.* (22) and Tang *et al.* (24), the reported PPR and MTR may be underreported as the result of patients' preference for off-site medical services.

Data with regard to chief complaint were complete; however, missing data with regard to demographics (*e.g.*, gender, age) were an issue in this study. Between legibility issues and the constraints on time to document during surges, multiple data fields were affected. To address this issue, moving forward in 2013, we trialed a new data collection strategy at a 2-d electronic dance music festival, and we were able to achieve data capture close to 100% by putting pairs of data monitors in main medical. PEFs are reviewed "in real time" by the data monitors, and if there are missing data fields, the forms are returned immediately to the clinicians for completion.

Future Directions

Arguably an important factor in improving outcomes for injured and ill spectators and participants is obtaining accurate data about patient encounters. Also there is a need for formalized study of the impact of MG and MP events on the medical infrastructure of the surrounding community. We need to learn, for example, the degree to which paramedic workload and response times are altered and the influence of such events on local emergency departments. This knowledge will support event planners, medical directors, and community stakeholders in providing medical support that minimizes the impact of special events on local community service levels. Ongoing efforts to create accurate models for the prediction of injury and illness rates at MP (and MG) events will be valuable. Such models will support event planners and medical directors in providing comprehensive on-site medical systems that protect the health of the public who attend and/or participate in such events and the emergency health system resources available for the general public.

Conclusions

In this manuscript, we have confirmed the stability of illness and injury rates for the VIM over 6 yr. This knowledge is useful in planning a response for future marathons and provides some direction for future inquiry. We compared the ATR and MTR for the present event with those for similar comparison events and found a larger number of medical staff with higher levels of training for the VIM; we surmise that this may have resulted in lower ATR and MTR. Prospective data collation and sharing are a valuable investment in time and energy and will permit a much greater understanding of the injury and illness burdens associated with various categories of events and the establishment of early evidence-based guidelines for MG and MP events' safety.

Acknowledgments

We thank the Lions Gate Hospital Foundation for providing a grant supporting this work. And, we thank Mr. Jordan Myers for his thoughtful review and contributions to this manuscript.

The authors declare no conflicts of interest.

References

1. Armstrong LE, Epstein Y, Greenleaf JE, *et al*., American College of Sports Medicine. Position Stand: heat and cold illnesses during distance running. *Med. Sci. Sports Exerc.* 1996;28:i–x.
2. Caselli MA, Longobardi SJ. Lower extremity injuries at the New York City Marathon. *J. Am. Pod. Med. Assoc.* 1997;87:34–7.
3. CBC News. Autopsy ordered in Montreal marathon death. 2011. Available from: *http://www.cbc.ca/news/canada/montreal/story/2011/09/26/autopsy-ordered-for-man-who-died-in-montreal-marathon.html*. Accessed on: May 6, 2012.
4. Chiampas G, Jaworski CA. Preparing for the surge: perspectives on marathon medical preparedness. *Curr. Sports Med. Rep.* 2009;8:131–5.
5. Crouse BJ. Marathon day. A view from the medical tent. *Minn. Med.* 1996; 79:10–1.
6. Environment Canada (2012). Available from: *http://www.weatheroffice.gc.ca/canada_e.html*. Accessed on: January, 2012.
7. Gutman SJ, Lund A, Turris SA. Medical support for the 2009 World Police and Fire Games: a descriptive analysis of a large-scale participation event and its impact. *Prehosp. Disaster Med.* 2011;26:33–9.
8. Jaworski CA. Medical concerns of marathons. *Curr. Sports Med. Rep.* 2005;4:137–43.
9. Kim JH, Malhotra R, Chiampas G, *et al*. Cardiac arrest during long-distance running races. *N. Engl. J. Med.* 2012;366:130–40.
10. Klien S. Despite Three deaths in Detroit race, runner fatalities are rare. 2009. Available from: *http://www.cnn.com/2009/HEALTH/10/20/health.marathon.fitness/index.html* Accessed on: May 6, 2012.
11. Lampa R. Running USA's annual marathon report. 2011. Available from: *http://runningusa.org/node/76115*. Accessed on: May 6, 2012.
12. Lund A, Skitch S, Chew A, *et al*. Cardiac arrest of a 31-year-old healthy female in a 10 km fun run. *Am. Med. Assoc. J. Summer* 2012:10–11. Available from: http://business.highbeam.com/3858/article-1G1-297829604/cardiac-arrest-and-resuscitation-31yearold-healthy.
13. Lund A, Turris SA, Amiri N, *et al*. Mass gathering medicine: creation of an online event and patient registry. *Prehosp. Disorder Med.* 2012;27:601–11.
14. Lund A, Wong D, Lewis K, *et al*. Text messaging as a strategy to address the limits of audio-based communication during mass-gathering events with high levels of ambient noise. *Prehosp. Disorder Med.* 2012;28:1–7.
15. Mass Gathering Medicine Interest Group (2013). Accessed on: October 21, 2013. Available from: http://www.mgmcanada.ca/.
16. National Post. Runner's death overshadows Mungara's 4th Toronto marathon win. 2011. Available from: http://sports.nationalpost.com/2011/10/16/runners-death-overshadows-mungaras-4th-toronto-marathon-win/. Accessed on: May 6, 2012.
17. Nguyen RB, Milsten AM, Cushman JT. Injury patterns and levels of care at a marathon. *Prehosp. Disorder Med.* 2008;23:519–25.
18. Redelmeier DA, Greenwald JA. Competing risks of mortality with marathons: retrospective analysis. *BMJ.* 2007;335:1275–7.
19. Roberts WO. A 12-yr profile of medical injury and illness for the Twin Cities marathon. *Med. Sci. Sports Exerc.* 2000;32:1549–55.
20. Salhanick SD, Sheahan W, Bazarian JJ. Use and analysis of field triage criteria for mass gatherings. *Prehosp. Disorder Med.* 2003;18:347–52.
21. Sanchez LD, Corwell B, Berkoff D. Medical problems of marathon runners. *Am. J. Emerg. Med.* 2006;24:608–15.
22. Satterthwaite P, Norton R, Larmer P, Robinson E. Risk factors for injuries and other health problems sustained in a marathon. *Br. J. Sports Med.* 1999; 33:22–6.
23. Shah W. Mass gathering medical care: to calculate the medical usage rate of Galway Races. *Am. J. Disaster Med.* 2010;5:61–4.
24. Tang N, Kraus CK, Brill JD, *et al*. Hospital-based event medical support for the Baltimore Marathon, 2002–2005. *Prehosp. Emerg. Care.* 2008;12:320–6.
25. Turris SA, Lund A. Triage during mass gatherings. *Prehosp. Disorder Med.* 2012;27:1–5.
26. Van Middelkoop M, Kolkman J, Van Ochten J, *et al*. Prevalence and incidence of lower extremity injuries in male marathon runners. *Scand. J. Med. Sci. Sport.* 2008;18:140–4.
27. Zeitz KM, Zeitz CJ, Arbon P. Forecasting medical work at mass-gathering events: predictive model versus retrospective review. *Prehosp. Disaster Med.* 2005;20:164–8.