ORIGINAL RESEARCH

Practical Solutions for Injury Surveillance at Mass Gatherings

Kathryn Zeitz, BN, MN, PhD;[1] Chris Zeitz, MBBS, PhD;[2] Paul Arbon BSc, MEd(Studies), PhD;[3] Fiona Cheney, BN, BA, MSocSc;[4] Renee Johnston;[4] James Hennekam[4]

1. Chief Nursing Officer, St. John Ambulance Australia SA Inc., Australia
2. State Medical Officer, St. John Ambulance Australia SA Inc., Australia
3. Professor of Nursing (Population Health), Flinders University; Chief Commissioner, St. John Ambulance Australia Inc., Australia
4. St. John Ambulance Australia SA Inc., Australia

Correspondence:
Kathryn Zeitz
St. John Ambulance Australia SA Inc.
85 Edmund Avenue
Unley 5061
South Australia
E-mail: chief.superintendent@stjohn.org.au

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Abstract

Introduction: Public safety at mass gatherings is the responsibility of multiple agencies. Injury surveillance and inter-agency communication are pivotal to ensure continued public safety.

Objectives: The principal objective of this pilot study was to improve the identification of trends and patterns of injury presentations at mass gatherings. This was achieved through an electronic process for data gathering to support timely reporting of injury data. In addition, what evolved was the development of an inter-agency communication model to support information transfer.

Methods: An Electronic Injury Surveillance System was created and piloted at two mass gatherings in South Australia. Live, real-time data were collected via customized software supported by electronic report generation.

Results: The Injury Surveillance System captured data on 181 injured patients and assisted in the identification of trends and patterns of presentations. The relevant injuries and patterns of injuries were reported to the appropriate organizations based on pre-defined communication models.

Conclusions: The pilot study demonstrated that it was possible to perform "live", portable injury surveillance during patient presentations at two mass gatherings. The Injury Surveillance System ensured immediate data capture. Well-defined communication systems established for this pilot also enabled early action to rectify hazards. Further development of electronic injury surveillance should be considered as an essential tool for managing public safety at mass gatherings.

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Introduction

"Injury surveillance data provides an important framework for all our prevention activities and serves as the cornerstone for evaluating the impact of these efforts".[1] However, there is limited information available on injury surveillance systems at mass gatherings. Often, the information focuses on outcomes of the injury or causative factors (injuries that resulted in presentations to the emergency department, hospital admissions, and/or workers compensation claims or deaths).[2] Other injury surveillance data focus on specific injury types (e.g., spinal injuries) or mechanisms of injury (e.g., traffic accidents, drowning).

Currently, no detailed analysis of injury patterns or injury follow-up in the mass-gathering setting has been published. Where patient presentations are discussed in the mass-gathering literature, they simply are listed as a descriptive diagnostic code.[3–5]

St. John routinely collects comprehensive data related to patient presentations and treatments utilizing a paper-based system known as a "Casualty Report". Patient data traditionally have been collated at the end of an event to determine the number of patients that presented and the quantity of work. The use of an electronic database that could assist in the collection and collation of "live" data and track the type, cause of injuries, and geographical locations of injuries in real time was identified as a need. This would enable a

more timely response to be initiated to improve public safety during the event.

This pilot study was conducted to improve the identification of trends and patterns of injury at mass gatherings. This was achieved through the integration of an electronic process for data collection to support timely reporting of injury data. The application of customized software supported live, real-time collection and reporting of injury data. In turn, this facilitated the establishment of an interagency collaboration for improved models of communication at two mass gatherings in South Australia.

Methods

This pilot study involved the development of a system to enable electronic injury surveillance. A number of organizations are involved in promoting safety at mass gatherings in South Australia. At all mass gatherings in South Australia, St. John Ambulance Australia, a national, not-for-profit, volunteer organization, has the primary function of providing a first-line response to injury and illness. Workplace Services South Australia oversees compliance with South Australian safety legislation, ensuring the provision of high standards of public health, safety, and welfare at mass gatherings. To maximize public order and safety, the South Australian Police also provide planning and operational support for major events.

A pre-existing database application (Microsoft Access, version 2003, Microsoft Inc., Redmond, WA) was used to develop the St. John Injury Surveillance System. The software enabled the data capture of demographic information from each patient supported by details relating to the injury. This included type of injury, causative factors, and location based on grid map references. The software enabled the electronic population of demographic data onto a standard casualty report used to record treatment details. This process reduced the number of times the patient had to answer the same questions and improved the quality and flow of the information collected.

As the focus of this study was injury identification and hazard reduction, specific exclusion criteria were developed. Excluded were:

1. All medical presentations (e.g., headache);
2. Blister and uncomplicated splinter injuries due to the minor nature and the minimal impact on work injury claims; and
3. Injuries that occurred outside of the event grounds.

Included in the study, and entered into the database were all patients who presented to the St. John first-aid service with an injury that occurred on the event grounds. Treatment details were excluded.

"The definition of injury is fraught with challenges and complexities". Traditionally, injury was considered as any damage to the body. More recent discussions have focused on defining injury in relation to the damage caused, the causative factor, and the resultant outcome.[6] For the purpose of this study, an *injury* is defined as damage to an individual caused by an external force that results in pain or disability.

Data collectors with an advanced first-aid qualification (resuscitation, defibrillation) were employed and provided with an orientation session regarding project and data entry requirements. They were stationed at the central first-aid room of the events. Their role was to triage patients, assess and enter the patient presentation data electronically, and print the casualty report. Triage data were determined as the most consistent, easiest, and earliest data to survey. Then, the data collectors could generate paper copy incident reports to be provided to appropriate agencies for the investigation of any hazards identified.

Injury Surveillance was performed at two major, annual events in South Australia in 2004: (1) the Oakbank Easter Racing Carnival; and (2) the Royal Adelaide Show. First, a trial of injury surveillance was conducted at the Oakbank Easter Racing Carnival, testing the database and workflow process. Oakbank is a two-day horse-racing carnival, and usually attracts at least 40,000 people daily. Oakbank was selected because all significant injuries presented to the on-site first-aid service (St. John Ambulance Australia), Workplace Services were on call (not on-site), and event organizers arranged their own Medical Officers to treat injured jockeys.

The pilot Injury Surveillance System used at the Oakbank Races was refined for application at the Royal Adelaide Show in 2004. The changes reflected improved work flow, reduction of data duplication, and technical changes to enhance reporting capability. The Royal Adelaide Show was chosen as the principal mass gathering for the study based on previous work.[4,7,8] The Royal Adelaide Show, an agricultural and horticultural show, has an average attendance of 616,000 patrons over the nine days. While St. John and Workplace Services are on-site, there are no rostered Medical Officers.

The Injury Surveillance System enabled the automatic generation of incident reports to facilitate improved, interagency communication. Prior to both events, a planning workshop was convened to describe the injury surveillance system being developed by St. John, and to develop communication systems between stakeholders. A flow chart was developed to define the classification of injury, type of injury, and flow of incident reports. A mechanism for reporting incidents also was devised for each event to assist with the transfer of information between organizations. Surveillance reporting was de-identified. Subsequent workshops with the stakeholders were held to evaluate the systems and make recommendations for improvements.

Data were extracted from the Injury Surveillance System onto a spreadsheet. Injury categorization arose from thematic analysis of presenting problems because current injury and disease surveillance constructs did not apply to the mass-gathering setting. Evaluation of the study involved descriptive statistical processing of the data obtained including frequencies, distributions, rates and means, and qualitative thematic evaluation of the communication process.

Ethical clearance for this study was granted by the National Research and Ethics Committee, St. John Ambulance Australia Inc. Specific ethical considerations for this study were the confidentiality and anonymity of the participants, in line with the St. John Privacy Policy and National Privacy Principles.[9] Data were stored securely,

Year	Attendance	Patients Treated	Ambulance Transfers
2002	107,200	71	Not available
2003	113,338	119	None
2004	113,584	136	2

Table 1—Summary of Oakbank Easter Racing Carnival for 2002–2004

Year	Attendance	Patients Treated	Ambulance Transfers
1995	637,996	1,021	Not Available
1996	651,733	1,272	14
1997	608,456	1,030	16
1998	631,947	1,021	29
1999	623,372	1,192	28
2000	577,341	867	23
2001	585,559	1,014	17
2002	622,234	1,028	48
2003	636,018	1,092	21
2004	601,529	782	6

Table 3—Patients treated and ambulance transfers Royal Adelaide Show

both electronically and in hard copy. Data were de-identified for processing, and only the principal researcher and project officer had access to the raw data.

Results

Oakbank Racing Carnival Pilot

The number of patient presentations from 2002–2004 at the Oakbank Easter Racing Carnival are depicted in Table 1. In 2004, over the two-day period, of a total 136 patients were treated, 41 patients presented with an injury. Patient presentation and transport to hospital rates are summarized in Table 2. A total of 36 patients were captured on the electronic injury surveillance system. All omissions occurred on the first day while trying to establish a rigorous process to support the Injury Surveillance System.

The collection of injury profile data highlighted opportunities to investigate the presence of a hazard. For example, it revealed six injuries related to six amusement rides. The system identified that seven of nine patients with

Day of the Week	Patient Presentation Rate/1,000	Transport to Hospital Rate/1,000	Injury Rate/1,000
Saturday	1.2	0	0.3
Monday	1.2	0.01	0.4
Total	1.2	0.01	0.4

Table 2—Oakbank Easter Racing Carnival injury rates, 2004

stings were located in close proximity based on grid references. A total of seven injuries were related to falls and fences, and four minor injuries were related to horses. One injured casualty required sutures by the on-site Medical Officer. Five casualties were referred for ongoing medical review, and three patients required transport to a hospital. One patient refused the recommended hospital review.

Royal Adelaide Show

Crowd attendances, patients treated at the Royal Adelaide Show, and ambulance transfers to hospital for the past 10 years are outlined in Table 3. The usual range of treatments were required in 2004; 269 patients with headache, 197 casualties with wounds, 12 with respiratory complaints, and two patients with chest pain.

Due to the application of a more refined process, the omissions that occurred during the Easter Racing Carnival event were avoided and the data from all injured patients who sought treatment were captured, even if the injury occurred days prior to presentation. The system enabled data capture on a total of 145 patients, with 113 patients meeting the study criteria. The daily range was 5–22 persons with injuries.

The total number of patients treated each day of the Royal Adelaide Show is detailed on the Injury Surveillance System, depicted in Table 4. The injuries sustained by patients who met the criteria totaled to 22% of the St. John workload. Less than 6% of patients who met study criteria were referred to Workplace Services.

Data abstraction from the Injury Surveillance System indicated that there were 58 injured females and 55 males. The mean value of the ages of the injured patients was 26 years (n = 102, with 11 unknown). Types of injuries captured on the Injury Surveillance System generally were minor. Injuries ranged from lacerations (n = 34), sprains to a joint (n = 24), bruises (n = 15), and a patient who was unconscious as the result of a seizure. The primary diagnosis of the injured casualties who met study criteria (n = 113) are listed in Table 5.

An analysis of causative trends for lacerations indicated the causes were varied. However, most were attributed to contact with sharp objects (knives, metal edges) or being hit by moving objects (machinery, vehicles, and displays). Descriptive data collected via the Injury Surveillance System on the cause of other injuries are depicted in Table 6. Of the show rides, no particular ride was identified as

Day	Date (day/month/year)	Total Patients	Patients Entered on St John Injury Surveillance System	% of St John Workload	Immediate Referral to Workplace Services
Friday	3/09/04	76	17	22	4
Saturday	4/09/04	120	22	18	6
Sunday	5/09/04	98	14	14	6
Monday	6/09/04	120	8	7	0
Tuesday	7/09/04	53	5	9	1
Wednesday	8/09/04	82	10	12	2
Thursday	9/09/04	109	22	20	2
Friday	10/09/04	59	7	12	1
Saturday	11/09/04	65	8	12	1
Total		782	113	14	23

Table 4—Royal Adelaide Show patients presenting to St. John and patients entered on St. John Injury Surveillance System

Primary Diagnosis	Total Number of Patients n (%)
Laceration	34 (30.1)
Sprain	24 (21.2)
Bruises	15 (13.3)
Abrasion	9 (8.0)
Burn	9 (8.0)
Eye Irritation	8 (7.1)
Suspected Dislocation	4 (3.5)
Minor Head injury	3 (2.7)
Bites	2 (1.8)
Unconscious	1 (0.9)
Eye swelling	1 (0.9)
Crushed finger	1 (0.9)
Burn to eye	1 (0.9)
Other	1 (0.9)
Total	113 (100)

Table 5—Primary diagnosis of patients who met study criteria for diagnosis

Cause of Injury	Total Number of Patients n (%)
Show Ride	17 (23.0)
Slip/Trip/Fall	13 (17.6)
Animal related	7 (9.5)
Protruding fence/rail	7 (9.5)
Fight	5 (6.8)
Showgrounds	4 (5.4)
Collapsed/seizure—Unknown cause	1 (1.4)
Hot water Burn	1 (1.4)
Friction Burn	1 (1.4)
Lighter Burn	1 (1.4)
Loading Gun	1 (1.4)
Unknown	13 (17.6)
Other	3 (4.1)
Total	74 (100)

Table 6—Causes of injuries at showground

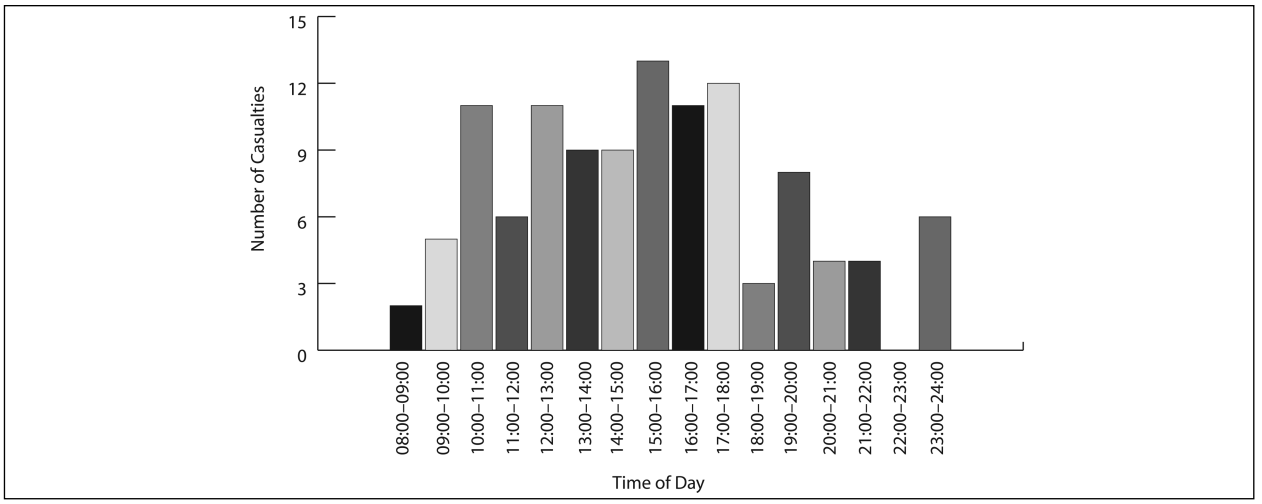

Figure 1—Time of injured patients presentation at the Royal Adelaide Show

more hazardous than another. There were no serious injuries reported as a result of the show rides, and there was no trend identified for slips or trips.

The Injury Surveillance System also assisted in identifying the time of day that a patient presented to St. John. The presentation time combined for the nine days is depicted in Figure 1, showing, despite a peak at 10:00 h, there are consistent presentations from 12:00–18:00 h.

The geographical location in which the injuries occurred, using grid reference, to assist hazard identification was included on the Injury Surveillance System. It was not possible to survey grid references electronically. A retrospective, manual review of the grid reference location of injuries revealed two re-occurring locations for injuries.

Discussion

Mass gatherings are unique because of their temporary nature, the multiple factors that impact on the event and the unique inter-organizational collaboration required to stage the event successfully. Various agencies administer different services in relation to the provision of a safe environment for patrons and employees working on-site.[10] Planning and inter-agency coordination are essential to assure the delivery of appropriate health care and to provide a safe working environment. This includes well-defined communication channels to ensure a safe mass gathering, and in the event of patron injury, there must be an effective way of collating and communicating injury data.

This pilot study focussed on designing an electronic injury surveillance system for patrons at mass gatherings. This was intended to improve current safety management practices by collecting and reporting information on injured patients at the time of presentation. This study revealed two elements: (1) electronic injury surveillance at mass gatherings is achievable; and (2) more rigorous injury surveillance is an enabler for more coordinated inter-agency communication.

The development of a real-time Injury Surveillance System supported electronic data capture and comprehensive reporting. Using a commercial database significantly reduced the development cost and enabled in-house programming. The system was easy to implement in the mass-gathering setting. It only required a laptop computer and portable printer. It was important for the first-aid providers to support the electronic data collection process. This was enabled by providing an easy-to-use system and ensuring that there was integration of the electronic information collected onto existing casualty reports. This reduced the amount of information the treating providers had to complete and reduced the number of times a patients was asked the same set of questions. The surveillance system opens opportunities for the development of an electronic record for the future.

The system was reliable in capturing patient presentations relating to injuries. A manual review of casualty reports revealed only three injuries that were not captured by the Injury Surveillance System. These injuries were minor, and may have occurred off of the event grounds or may have been old injuries.

The Injury Surveillance System enabled easier extraction of traditional mass-gathering indicators in a consistent format than previously achieved from paper-based reviews. The results of this study demonstrate similar trends in relation to patient presentation rates and hospital transport as documented in other mass-gathering descriptions. Importantly, the ease of data extraction provides a benchmark and will facilitate future data comparisons.

Nearly one-quarter of the patient presentations related to injuries sustained at the event. Despite this, only a small number of hazards were investigated, such as a cluster of stings and amusement ride injuries. Due to the limitations of the software, the surveillance was required to identify the pattern of location of injuries relied on a manual review of the grid reference used to locate the location where injuries occurred. It also was challenging because it was discovered that there were three different operational maps being used for grid reference location. It is uncertain if manual grid reference review is the optimal way to identify the location of potential hazards.

While this pilot project demonstrated that it is possible to perform real-time, electronic surveillance at mass gatherings, it also has highlighted numerous possibilities. Real-time electronic surveillance can support more timely and responsive actions to potential or actual problems in the dynamic setting of mass gatherings. The application of patient surveillance to capture patient presentations that might be indicative of other mass-gathering hazards (such as nausea or respiratory complaints) must be considered. This includes the identification of clinical problems such as cluster presentations of injuries relating to an existing hazard or illness resulting from environmental changes. It also facilitates the collation of data to reinforce operational decision-making affecting the deployment of resources or changes to treatments. An example might be seeking advice from a specialist about an emerging clinical problem or the acquisition of specialized resources sooner rather than later.

The categorization of injury presentations grew from thematic interpretation of the data captured. Current injury and disease constructs focus on outcomes of the injury or causative factors. These factors include injuries that resulted in presentations to the emergency department, admission to a hospital, and workers compensation claims or deaths.[2] Other injury surveillance data focus on specific injury type (e.g., spinal injuries) or mechanisms of injury (e.g., traffic accidents, drowning). A construct to classify medical work generated at mass gatherings must be developed to integrate traditional injury and illness groupings because at mass gatherings, the degree of separation between these two groups is minimal.

The ability to collect and interpret real-time data and generate electronic reports provided an opportunity for the electronic transfer of information, and was a successful tool for increasing inter-agency communication. Prior to the study, agency stakeholders identified that the lines of communication and the types of communication between organizations had not been well-specified. Pre-event stakeholder workshops resulted in the development of communication flow charts, and assisted in clarifying the types of information each organization required and the timelines for reporting. This enabled information sharing that was consistent with local privacy requirements. Feedback from both evaluation workshops highlighted that the flowcharts, and improved communication processes. Therefore, the level of reporting generated from the Injury Surveillance System was significantly better than in the past.

A pre-determined system for stakeholder communication is pivotal to any effective injury surveillance system. It is recommended that operational plans for mass gatherings clearly specify the communication processes and the level of reporting required by the organizations involved in ensuring public safety.

Developments planned for the future include surveillance of presentations more generically to identify other trends such as gastrointestinal disturbances, which may indicate episodes of food poisoning or disturbances that may indicate environmental factors resulting from chemical and biological accidents. The goal is to integrate the St. John Injury Surveillance System with a casualty report database, which would enable prospective data collation of presentations and treatments at mass gatherings. This would save duplication of data entry and offer more comprehensive reporting in a timely manner. The possibility of the introduction of additional hardware such as networked pocket PCs, to provide data from all field teams also could be investigated.

Conclusions

Injury surveillance is important in maintaining public safety management at mass gatherings. To date, injury surveillance at mass gatherings has involved manual review of individual patient records. Electronic injury surveillance makes sense, enabling timely response to rectify hazards identified.

This pilot study demonstrated that it is possible to perform live injury surveillance at mass gatherings. Injury surveillance systems alone do not improve public safety. They must be supported by a well-defined communication process so the correct information is provided to the appropriate agencies in the right timeframe. Important elements of surveillance systems for mass gatherings include portability, ease of use for a broad range of providers, and compatibility with current operational systems. The success of this pilot was due in part to the fact that the Injury Surveillance System added value without creating additional work, provided electronic data capture not previously achieved, and enabled an appropriate level of summative reporting in a usable format to a variety of service providers.

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