ORIGINAL RESEARCH

Variables Influencing Medical Usage Rates, Injury Patterns, and Levels of Care for Mass Gatherings

Andrew M. Milsten, MD, MS, FACEP;[1] Kevin G. Seaman, MD FACEP;[2] Peter Liu, MD;[3] Rick A. Bissell, PhD;[4] Brian J. Maguire, MSA, PhD, EMT-P[5]

1. Assistant Medical Director, Anne Arundel County Fire Department; Assistant Professor, University of Maryland, Division of Emergency Medicine, Department of Surgery, Baltimore, Maryland USA
2. Co-Director, EMS Fellowship Program, Assistant Professor, University of Maryland, Division of Emergency Medicine, Department of Surgery, Baltimore, Maryland USA
3. Emergency Medicine Resident, Division of Emergency Medicine, Department of Surgery University of Maryland School of Medicine, Baltimore, Maryland USA
4. Co-Director, EMS Fellowship Program, Associate Professor, University of Maryland-Baltimore County, Department of Emergency Health Services, Baltimore, Maryland USA
5. Associate Director of Graduate Program, Department of Emergency Health Services, University of Maryland-Baltimore County, Baltimore, Maryland USA

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Correspondence:
Andrew Milsten, MD, MS, FACEP
Emergency Department North Arundel Hospital
301 Hospital Drive
Glen Burnie, Maryland 21061 USA
E-mail: amilsten@aol.com

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Abstract

Objectives: Mass gatherings create difficult environments for which to plan emergency medical responses. The purpose of this study was to identify those variables that are associated with increased medical usage rates (MURs) and certain injury patterns that can be used to facilitate the planning process.

Methods: Patient information collected at three types of mass gatherings (professional American football and baseball games and rock concerts) over a three-year period was reviewed retrospectively. Specific variables were abstracted: (1) event type; (2) gender; (3) age; (4) weather; and (5) attendance. All 216 events (total attendance 9,708,567) studied were held in the same metropolitan region. All MURs are reported as patients per 10,000 (PPTT).

Results: The 5,899 patient encounters yielded a MUR of 6.1 PPTT. Patient encounters totaled 3,659 for baseball games (4.85 PPTT), 1,204 for football games (6.75 PPTT), and 1,036 for rock concerts (30 PPTT). The MUR for Location A concerts (no mosh pits) was 7.49 PPTT, whereas the MUR for the one Location B concert (with mosh pits) was 110 PPTT. The MUR for Location A concerts was higher than for baseball, but not football games (p = 0.005). Gender distribution was equal among patrons seeking medical care. The mean values for patient ages were 29 years at baseball games, 33 years at football games, and 20 years at concerts. The MUR at events held when the apparent temperature was £80°F significantly lower statistically than that at events conducted at temperatures <80°F were (18°C) (4.90 vs. 8.10 PPTT (p = 0.005)). The occurrence of precipitation and increased attendance did not predict an increased MUR. Medical care was sought mostly for minor/basic-level care (84%) and less so for advanced-level care (16%). Medical cases occurred more often at sporting events (69%), and were more common than were cases with traumatic injuries (31%). Concerts with precipitation and rock concerts had a positive association with the incidence of trauma and the incidence of injuries; whereas age and gender were not associated with medical or traumatic diagnoses.

Conclusions: Event type and apparent temperature were the variables that best predicted MUR as well as specific injury patterns and levels of care.

Abbreviations:
AMA = against medical advice
BB = baseball games
EMS = Emergency Medical Services
FB = [US] football games
LOI = location of injury
MGMC = mass gathering medical care
MOI = mechanism of injury
MUR = medical usage rate
PPTT = patients per 10,000
RC = rock concerts

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Introduction

People love to gather for public events of all kinds, including sports competitions, concerts, and fairs. Millions of people attend mass gathering events every year—5.5 million at [US] National Association for Stock Car Automobile Racing (NASCAR) events and 165 million at professional or college baseball or [US] football competitions.[1,2] Although mass gatherings tend to be collections of "well persons", an effective emergency medical system capable of handling any life-threatening condition must be in place and ready to respond immediately, because the incidence of illness and injury during such events has been higher than for the general population.[3–5]

Mass Gathering Medical Care (MGMC)

Events with >1,000 people in attendance have two primary goals: (1) provision of on-site event medical care; and (2) preservation of the emergency medical services (EMS) system for the rest of the service area.[2,6–8] On-site medical care encompasses rapid access to the patient, triage, stabilization, and transport to site facilities designed to handle minor injuries and illnesses.[9–10] Mass Gathering Medical Care (MGMC) must include the capability to respond to cardiac emergencies with the rapid delivery of Advanced Cardiopulmonary Life Support (ACLS).

Pre-event needs analysis will drive appropriate planning and facilitate better utilization. Early in the evaluation, numerous variables likely to be present must be considered, and a medical usage rate (MUR) must be estimated. If associations between variables and the MURs for mass gatherings can be identified, these relationships could enhance the planning process. The primary goal of this study was to examine these relationships. Furthermore, this study examined injury patterns and levels of care associated with these variables. This study examined event type (which includes crowd mobility and event duration), weather temperature and precipitation, attendance, age, and gender.

Methods

A retrospective review of medical care reports was conducted for all patients who presented to the first-aid stations at three mass-gathering venues, during a three-year period (1997–1999) (Table 1). These venues included Major League Baseball, [US] National League Football, and rock concerts. The rock concerts were classified either as Location "A" in which the venue was outdoors, seats were covered, and lawn seating was available on the field, and Location "B" which were conducted in an open-air stadium. Due to the retrospective nature of the study, the institutional review board considered the study exempt from review.

All forms were collected and sorted by the primary author, who abstracted data from each medical form. Medical forms included first-aid and medication request forms, ambulance run sheets, and discharge against medical advice (AMA) forms. Similar first-aid and medication request sheets were used with the Baseball, Football, and Concert B events. For the Concert A events, a patient-tracking sheet and ambulance run forms were used. The data forms were completed on-site by nurses or physicians (Baseball, Football, and Concert B) or prehospital providers and physicians (Concert A).

The Public Relations office for each venue was contacted for attendance information. Weather data were obtained from the National Climatic Data Center website. Ambient temperature and relative humidity at the start of each event were abstracted. Using a graph of standard air temperature and relative humidity from the National Oceanic and Atmospheric Administration, apparent temperature (another measurement of heat index) was determined. Apparent temperatures are not accurate for ambient temperatures below 70°F (27°C); therefore, ambient temperatures were recorded for ambient temperatures of <70°F (27°C).

The diagnostic categories outlined by Mear and Batson were used,[12] with the additions of stabbing and altered level of consciousness from Grange.[13] Mean's heat/cold-related category was divided further into heat exhaustion, heat stroke, and cold-related (hypothermia). If more than one complaint was noted, the most immediate reason the patient sought medical care was considered as the chief complaint. The primary diagnosis was taken directly from the first-aid sheets. If no primary diagnosis was listed, the investigators assigned their best estimate based on the chief complaint and the narrative by the first-aid personnel.

Level of care was determined with the same treatment categories used by Grange (minor care, <5 minutes; basic care, 5–15 minutes; advanced care, >15 minutes), with the following alterations.[1] The minor category was assigned to patients presenting only for medication or bandage requests (recorded on a medication request form, not on a first-aid form). Physicians or nurses could dispense medications. The protocol at these facilities notes that if a patient requests medication for a traumatic injury or if the case appears to be serious (as judged by the triage nurse), a first-aid form must be filled out. Prehospital care providers at Concert Location A events could not dispense analgesics or other medications without a physician present, as it is outside of their scope of practice. Then, basic or advanced care was assigned based on the amount of time the patient was in the first-aid room. If complete first-aid room arrival and departure times were not recorded, the treatment category was assigned according to state advanced life support (ALS) and basic life support (BLS) protocols.

Group differences were evaluated using Pearson's chi-square test for categorical variables and analysis of variance (ANOVA) for continuous variables. Multiple comparisons between mean values were made using the Tukey-Kramer method. The strength of a linear relationship between two continuous variables was assessed using Pearson's correlation coefficient.

Medical usage was reported as a rate (patients per 10,000 [PPTT]), which was calculated by dividing the number of individuals seeking medical care by the total attendance for that event and multiplying by 10,000, in order to maintain consistency with the reports already reported. Poisson regression methodology, which is used to model the incidence of relatively rare events, was applied to compare the adjusted and unadjusted medical usage rates (MURs) for baseball games (BB), football games (FB) and rock concerts (RC). A probability level of <0.05 for a two-sided test was considered significant statistically.

Descriptive statistics were utilized where appropriate. The MUR calculations for rock concerts did not include Location B concerts. Also, age and gender MUR data only are reported descriptively. Furthermore, due to incomplete data collection, descriptive statistics were used for the following elements: (1) mechanism of injury (MOI); (2) location of injury (LOI); (3) secondary diagnosis; (4) type of medicine requested; and (5) alcohol or drug use.

Results

Medical Usage Rates (MUR)

A total of 5,899 events were analyzed: baseball = 3,609 (62%); football = 1,204 (20%); and concerts 1,036 (21%). Data were abstracted for 168 baseball games, 27 football games, and 21 concerts (Table 1). Mean values for the attendance figures for BB, FB, and RC are listed in Table 2. In general, attendance was higher at the sporting events: the mean attendance for football was >63,0000; for baseball, it was >45,000; and for concerts, it was >12,000. The lowest attendance occurred for a rock concert (4,000), and the highest for a football game (68,847) (Table 2). The mean value for MUR for all events combined was 6.00 PPTT, and was lowest for baseball (4.83 PPTT), for football was 6.75 PPTT, and for rock concerts was the highest at 30 PPTT (Table 3).

The differences in MUR between FB and BB were significant statistically (p <0.001) and also between RC and BB (p = 0.02). However, the difference in MUR between RC and FB was not significant statistically. The MUR at RC was marginally higher than was that at FB and BB combined (p = 0.06). The incidence of medical usage at RC was 54% higher than for BB (p = 0.02), and was 39% higher for FB than for BB (p <0.001; Table 3) Furthermore, the MUR for RC at Location B was seven times greater than that for Location A.

Within each of the three event types, the MUR for apparent temperatures >80°F (27°C) was higher (p = 0.005) than the MUR for events held in cooler temperatures (Table 3). The difference between MUR at RC with apparent temperatures >80°F (27°C) and ≤80°F was statistically significant (p <0.0000001).

Since attendance at an event is taken into account in the calculation of the MUR, it was anticipated that the MUR would be highly associated with the attendance figures. Due to the low correlation (0.18) between overall MUR and the number of persons in attendance; however, the effect of event type on the MUR was adjusted for the heat index (apparent temperature) and precipitation using a Poisson regression model. Analysis of event type, heat index, and precipitation showed a significant effect for event type (F = 10.65, p <0.001) and heat index (F = 8.47, p = 0.004). The relationships with precipitation were not significant statistically, and no interaction terms remained in the final model. Pair-wise comparisons of total MUR due to event type, adjusted for the heat index and precipitation, indicated that football spectators had a 41.7% higher MUR than those attending baseball games (p <0.001). In addition, concert-goers had a 49.0% higher MUR than did baseball spectators (p = 0.03). The MUR value for football was not significantly different from that seen at concerts. The MUR for events taking place in apparent temperatures warmer than 80°F (27°C) was 22.3% higher than that for events held in cooler weather.

Case Mix

The primary diagnosis case-mix is in Tables 4 and 5. Request for medication was the most common reason people sought medical care; (941, 16%) musculoskeletal injuries and dermal (741, 12%) ranked second and third for medicine respectively. More musculoskeletal and head injuries occurred at concerts (22.2%) than at other types of events (p = 0.001). Headache was the primary complaint of 7.6% of the 5,899 patients who came to first-aid stations.

Heat-related illnesses accounted for a large proportion of patient visits. There were more heat-related complaints at concerts, 17.3% (MUR = 5.2 PPTT; p = 0.001) and events with apparent temperatures >80°F (27°C) (87.1% at >80°F (27°C) vs. 45.6% at ≤80°F (27°C), p = 0.001). During the two football seasons, when medication request forms were not used, the recorded number of medication requests was lower, but the recorded number of headaches (the most common reason to ask for medications) was 20 times higher (see Table 6 for secondary diagnoses).

Trauma versus Medical Conditions

Each patient's primary diagnosis was classified either as due to trauma (31%) or medically related (69%) (Table 4). The medical category included requests for medication (38% of patient encounters) and patient encounters for which records are incomplete (1% of the total). More trauma-related events occurred at concerts (41.8%) than for either BB or FB (p = 0.001). There was no difference between FB and BB (p = 0.06). Rock concerts had significantly fewer medical cases than did sporting events.

Logistic regression was used to identify relationships between patient age, gender, weather, and event type for trauma and medical diagnoses. The odds ratio indicated that concert attendees were 30% more likely to have a trauma-related diagnosis (OR = 1.30, 95% CI = 1.08–1.57). Precipitation also was positively associated with a traumatic diagnosis (OR = 1.86, 95% CI = 1.37–2.54). Gender and age were not predictive of a traumatic or medical diagnosis (OR = 1.0, 95% CI = 0.99–1.0; OR = 0.99, 95% CI = 0.99–1.0, respectively).

Treatment Categories

Overall, 38% of patients needed minor care, 46% basic care, and 16% advanced care (Tables 5 and 7). Treatment categories were compared on the basis of apparent temperature

	Baseball (MLB)	Football (NFL)	Rock Concerts Location A	Rock Concerts Location B
Years available for review	1997–1998	1997–1999	1998–1999	1999
Events available for review	168	27	20	1
Event Location	Open-air stadium	Open-air stadium	Outdoor venue. Covered seats plus a field of low-grade with seating	Open-air stadium
Medical forms used	FA, MR, AR	FA, MR, AR	PTS, AR	FA, MR, AR
Medical staff on-site	RN, MD, PH	RN, MD, PH	PH, MD	RN,MD, PH
Attendance	7,655,506	1,709,743	343,318 (75,000 at location B)	
Patients	3,659	1,204	1,036	

Table 1—Methods table: MLB = Major League Baseball. NFL = National Baseball League. NFL = National Football League; Medical Forms: FA = first aid form; MR = medication request form; AR = ambulance run sheet; PTS = patient tracking sheet. Medical Staff RN = nurses; MD = physicians; PH= prehospital providers; Dependent Variables shared by all events: (1) outdoors and held within the same metropolitan region; (2) similar medical infrastructures, restroom facilities, and pricing of basic necessities (food and water). All served alcohol; (3) suturing, laboratory, and radiologic capabilities were not available; (4) physicians were on-site for the majority of events, except the concerts with smaller attendances; and (5) analgesics available for patients

Event Type	Observed Games	Total Games	Mean	Minimum	Maximum
Baseball	168	168	45,568	36,288	49,090
Football	27	27	63,323	53,976	68,847
Concert	21	21	12,777	4,000	19,418

Table 2—Average number of persons in attendance by event type

for all events combined. Basic and advanced care were provided more frequently at events with temperatures >80°F (27°C) (basic: ≤80°F = 47.4%, 80°F (27°C) = 52.6%) (advanced: <80°F (27°C) 41.4%, >80°F (18°C) = 58.6%, p = 0.001). Minor care was provided more frequently at events with apparent temperatures ≤80°F (27°C) = 59.7% vs. >80°F (27°C) = 40.3%, p = 0.001). At temperatures >80°F (27°C), advanced care was provided more than minor and basic care combined (58.6% vs. 47.0%, p = 0.001).

Traumatic versus medical diagnoses were examined with respect to these treatment categories. Most traumatic diagnoses required basic care (minor care, 16.0%; basic, 83.8%; advanced, 16.1%; p = 0.001), whereas most medical diagnoses needed only minor care (minor, 55.2%; basic, 29.0%; advanced, 15.7%; p = 0.001). However, when medication requests were subtracted, most medical diagnoses required basic care (minor, 0%; basic, 64.8%; advanced, 35.2%; p = 0.001).

Patient Disposition

The dispositions of patients were categorized as treat-and-release, transport (to hospital), leaving against medical advice (AMA), sent home, or other (e.g., being sent to a cool-down room) (Table 7). Treat-and-release was the most common disposition for patients at all event types. Concerts had the highest percentage of transports, followed by patients leaving AMA, and patients sent home or to an alternative site.

Mechanism of Injury and Location of Injury

The mechanism of injury (MOI), location of injury (LOI), and medication requested are listed in Table 7. Thirty percent of first-aid forms (1,788 patients) had an available MOI. The most common traumatic MOI reported was 'other trauma', followed by falls/trip. Third was being hit with a foul ball, which occurred only at baseball games. The RC had injuries due to moshing, crowd surfing, as well as from missiles thrown from the crowd. Fights were the cause of 3.0% of the overall total, and occurred more often at football games.

Injuries occurred more frequently to the extremities (36% upper; and 25.8% lower) and to the head/neck (31.3%). Head and neck injuries were much more common at concerts (47.6%). Analgesics such as ibuprofen and acetaminophen were the most commonly requested medications.

Generally, the literature associates certain crowd demographics with different types of events. Descriptive statistics were used for age and gender data in the current study. The total MUR could not be compared statistically, because, even though the number of females versus males in the first-aid stations was quanitified, the total number of females versus males attending an event was an unknown (same was true for age data). The mean of the ages of the patients who presented at FB (33.5 years) was higher than was the mean of the age of people seeking medical care at BB (29.1 years) and at RC (25.8 years) (Tables 9–11). However, there was no significant difference in the ages between patients seeking care at BB and RC. The mean value of the ages of trauma patients and medical patients

	All Events	Baseball	Football	Location A Concerts
MUR	6.1	4.85	6.75	7.49
Apparent temp ≤80°F (27°C)	4.9	4.58	6.11	4.69
Apparent temp >80°F (27°C)	8.1	5.30	8.90	8.85

Table 3—Planning table. (MUR = Medical Utility rate as number of patients per 10,000 in attendance (PPTT)).Total MUR by event type and total MUR by apparent temperature; MUR for sporting events (BB+FB) = 5.20; MUR for Location B concert = 110; MUR for Location A+B concerts = 30

were not significantly different statistically (27.8 vs. 28.7, p = 0.09).

Discussion

Not all mass gatherings are equal. There are multiple variables that can change the character and flow of a mass-gathering event, and these can affect injury patterns and medical usage rates (MURs). Using retrospectively gathered data, this study examined weather, event type (which included crowd mobility and duration), gender, ages of the patients, and attendance.

Event type is considered an important variable associated with medical usage rates.[1,4,14–37] Because several other variables are integral within certain types of events, this relationship makes the event type key for determining injury patterns and possible MURs. For example, rock concerts generally draw a younger crowd (that is large and unruly) than are classical music events.[9,38] Different types of music draw different types of spectators, and crowd mood may play a role. Furthermore, rock concerts with mosh pits have higher MURs than non-rock concerts.[13,39] Other factors associated with different events are assigned seating versus general admission (football game versus a fair) and indoor versus outdoor locations. Most of the literature points toward increased MURs with increased event duration and crowd mobility.[22]

This study found event type to be a significant predictor of MUR. Rock concerts and FB had higher MURs than did BB, whereas there was no difference between FB and RC. There are several possible reasons for these findings. First, fans at FB demonstrate a more physical nature than do those fans at BB (more alcohol, more fights, possibly more crowd mobility). Second, the majorities of the RC studied were concert Location A type (Sander's Category 1xx) and lasted about six hours (slightly longer than sporting events); some fans sat under a pavilion and others moved freely on the field. Despite wide variations in content (Jimmy Buffet to heavy metal music), all were RC, but none had mosh pits, resulting in lower MURs than for those with mosh pits.[39] In contrast, the largest concert in the study (heavy metal and alternative music), at concert location B, had a duration of 12 hours and had multiple mosh pits and crowd surfers, leading to the largest MUR (110 PPTT). This Sander's Category 2xx concert was removed from MUR statistical calculations because it was a single event and considered to be an outlier. Rock concerts with longer durations, freely mobile crowds, mosh pits, and crowd surfers, will have higher MURs than will sporting events.

Temperatures >80°F (27°C) are associated with higher MURs. Therefore, when the apparent temperature during an event is predicted to be higher than 80°F (27°C), MGMC planners should expect more patient contacts.[6,12,19,.32,40]

In this study, the number of persons in attendance was a predicator of MUR, but, due to the low correlation, the size of the crowd does not explain much of the variance of the MURs. The number of attendees has been thought of as a good predictor of medical usage rate; certainly larger events have the potential to create more patients (by shear volume), but studies show a weak positive correlation while others show a weak negative correlation between the number of attendees and the MUR.[10,19,21,33,41] Size does not always predict MUR, though, as a riot at a small concert can produce many injuries, whereas the large Papal Mass in New York City's Central Park produced no patients.[13,20]

Case Mix

The most common reasons for seeking medical care (all events) in this study were medication requests, dermal and musculoskeletal injuries, headaches, heat exhaustion, gastrointestinal complaints, and other medical conditions. These findings are consistent with previously published reports, which show that most medical care required at mass gatherings is minor.[9,40,42]

Medication requests were more frequent at BB than at FB or RC. However, this finding most likely represents recording bias. Medication request forms were used for all baseball seasons studied, whereas these forms were used only during the 1999 football season. Previous to that season, medication requests were recorded at FB on standard first-aid report sheets (basic care assignment). The RCs, which used hardly any medication request sheets, had a similar pattern as did FB. Given the consistency in recording medication requests at BB, this type of event seems to represent a close approximation of the actual proportion of patient encounters (49%) that can be expected at mass gathering events (specifically sporting events). On the other hand, the number of bandage requests was very low, which likely represents another recording bias, as most of these requests are not documented.

Dermal and musculoskeletal injuries accounted for 28% of the patient encounters in this study. The incidence of dermal injuries was higher at FB than at other events, perhaps

	All Events		Baseball		Football		Rock Concerts	
	n	(%)	n	(%)	n	(%)	n	(%)
Total	5,899	(100.0)	3,659	(62)	1,204	(20)	1,036	(18)
Med Request	2,266	(18.0)	1,780	(49)	265	(22)	221	(21)
Bandage Request	17	(0.3)	1	(0.0)	1	(0.1)	2	(0.0)
Dermal Injury	741	(12.0)	425	(11.6)	183	(15.2)	126	(12.2)
Eye Injury	99	(1.7)	75	(2.0)	10	(0.8)	13	(1.2)
Foreign Body	11	(0.1)	7	(0.2)	10	(0.8)	2	(0.0)
CHI	32	(0.5)	7	(0.2)	3	(0.3)	22	(2.1)
Insect Bites	52	(0.9)	25	(0.7)	15	(1.2)	12	(1.1)
Musculoskeletal	941	(16.0)	556	(15.2)	132	(11)	230	(22.2)
Other Trauma	12	(0.2)	5	(0.0)	4	(0.3)	3	(0.0)
Abdominal Pain	41	(0.7)	34	(0.9)	4	(0.3)	3	(0.0)
Alcohol/Drug	79	(1.3)	8	(0.2)	12	(1.0)	59	(5.7)
Cardiac Arrest	5	(0.08)	4	(0.1)	1	(.08)	0	(0.0)
Chest Pain	51	(0.8)	36	(0.9)	15	(1.2)	0	(0.0)
Dehydration	51	(0.8)	13	(0.3)	6	(0.5)	25	(2.4)
Diabetes	23	(0.4)	15	(0.4)	4	(0.0)	4	(0.0)
Dizziness	52	(0.8)	24	(0.6)	16	(1.3)	12	(1.1)
Epistaxis	56	(0.9)	22	(0.6)	6	(0.5)	28	(2.7)
GI Complaints	130	(2.2)	102	(2.8)	21	(1.7)	7	(0.7)
Headache	455	(7.6)	126	(3.4)	280	(23.2)	47	(4.5)
Heat Exhaustion	354	(5.9)	172	(4.7)	39	(3.2)	142	(14)
Heat Stroke	1	(0.01)	1	(0.0)	0	(0.0)	0	(0.0)
Hypothermia	5	(0.08)	0	(0.0)	4	(0.3)	0	(0.0)
Hyper/Hypotension	13	(0.2)	4	(0.1)	8	(0.6)	0	(0.0)
OB/GYN	30	(0.5)	11	(0.3)	16	(1.3)	3	(0.0)
Other Medical	193	(3.2)	107	(2.9)	69	(5.7)	17	(1.6)
Resp. Distress	85	(1.4)	34	(0.9)	21	(1.7)	30	(2.9)
Seizure	23	(0.4)	16	(0.4)	3	(0.3)	4	(0.0)
Syncope	63	(1.0)	37	(1.0)	16	(1.3)	10	(0.9)
Altered LOC	11	(0.1)	3	(0.08)	4	(0.3)	4	(0.0)
Stabbing	0	(0.0)	0	(0.0)	0	(0.0)	0	(0.0)
No Record	63	(1.0)	9	(0.2)	44	(3.6)	10	(0.9)
Trauma-related	1,873	(31.0)	1064	(29)	331	(27)	434	(42)
Medical-related	4,082	(69.0)	2,595	(71)	873	(73)	602	(58)
Total Attendance	9,708,567	(100.0)	7,655,506	(78.9)	1,709,743	(17.6)	343,318	(3.5)

Table 4—Case-mix by primary diagnosis (The distribution of a categorical variable in a sample often needs to be compared with the distribution of a categorical variable in another sample]; Dermal = abrasions, lacerations, blisters; Musculoskeletal = contusions, sprains, strains, fractures; GI = gastrointestinal; OB/GYN = obstetrics/gynecology; Resp = respiratory; LOC = level of consciousness)

a reflection of the number of fights (9.5%). Also, football has been considered "more demanding" than baseball, because of alcohol use, team rivalry, and weather conditions.[32,38]

Rock concerts consistently manifest more traumatic injuries than for other types of events.[4,13,14,16,17,27,30,43-45] This higher incidence could be associated with several factors: (1) the presence of mosh pits and crowd surfing; (2) increased crowd mobility; (3) event duration; (4) younger age; and (5) alcohol use. In a mosh pit, groups of densely packed people push and slam into each other while moving about in a circle. Crowd surfing occurs simultaneously and consists of individuals being forcibly thrust from person-to-person (while above the crowd) in a stage-bound direction. Strauss commented that mosh pits' history of "alternative-rock apathy" has been replaced by "age old mob savagery".[46] Security measures at large venues have limited stage diving, turning water bottles into missiles, and using blankets to launch patrons into the air.

Head injuries were more common at RC than at any other event, and other authors have noted this as well.[13,27,45] The increased incidence of head injuries most likely results from moshing, crowd surfing, and being hit with missiles. Most head injuries were minor, and did not involve loss of consciousness.

Heat-related illness accounted for a large proportion of total number of patient visits and was more common at RCs. Several reasons can be postulated: (1) the concerts all

Case-Mix	Baseball %	Football %	Rock Concert %	Baseball + Football %	Baseball + Concert %	Football + Concert %	*p*-Value
Med Request	49	22	21	42	42.6	21.7	0.001
Dermal Injury	11.6	15.2	12.2	12.5	11.7	13.8	0.81,0.003,0.02
Eye Injury	2.0	0.8	1.2	1.7	1.9	1.2	0.27,0.024,0.07
Head Injuries	0.3	0.6	2.5	0.3	0.8	1.5	0.001,0.64,0.001
Musculoskeletal	15.2	11.0	22.1	14.1	16.7	16.2	0.001,0.001,0.22
Cardiac Events	1.1	1.3	0.0	1.1			0.001
Heat-Related Illness	5.7	5.1	17.3	5.6	8.3	10.7	0.001
Trauma-related	29.4	26.5	41.8	28.7			0.001
Medical-related	70.6	73.5	58.2	67.9			0.001
Treatment Categories							
Minor care	48.7	21.9	20.9	41.8			0.001
Basic care	35.8	63.5	61.7	42.7			0.001
Advanced care	15.8	14.5	17.4	15.5			0.001

Table 5—Case-mix by primary diagnosis and event group comparison. Case-mix and event group percentages are listed for each event. Statistical comparisons are provided between case-mix and event group by: baseball vs. football+concerts, football vs. baseball+concerts; and concerts vs. baseball+football. p-values are list in sequence for each comparison unless all p-values were identical. (Cardiac events = chest pain and cardiac arrest; head injuries = closed head injuries and altered level of consciousness)

occurred during the summer months; (2) the activity level (moshing, dancing, crowd-surfing) can lead to dehydration without proper fluid intake; and (3) the general admission policy can lead to increased crowd density (especially towards the front of the stage). Several problems during the concert at Location B led to larger episodes of heat-related illness: patrons were not allowed to bring bottled water into the stadium (later used as missiles), and the supplies of water (free and bottled for sale) ran low. Furthermore, most of the events took place on an un-shaded field, where many people were pushed together in close quarters and the apparent temperature was elevated. The high crowd density not only caused many people to become overwhelmed due to body heat, but also made access to shade and water difficult.

Patients with respiratory complaints can deteriorate rapidly, and some mass gathering conditions exacerbate their disease (high crowd density, dust stirred up by large crowds, field conditions, etc.).[6,9,18,28,45,47] The literature indicates that respiratory complaints constitute 0.7% to 14% of cases,[6,9,18,19,28,45,47,48] and for the current study, found 1.5%. Many patients with asthma seek medical care because they forgot or lost their meter-dose inhalers.[18,45,48] Most patients with respiratory problems are treated successfully at the scene with oxygen and bronchodilators, and many then signed out AMA. Symptoms usually recur and/or worsen throughout the day, but only a few patients comply with suggestions to leave the event.[18,19,28]

The incidence of cardiac-related complaints was not significantly different at FB or BB (none at RC). The FB cardiac arrest rate (0.03 PPTT), classical music concerts (0.0 19 PPTT), and on airplanes (0.08 PPTT) reportably has been higher than the general population average of 0.0062 PPTT.[10,12,13,35,40,49,50] This study had an overall sporting event cardiac arrest rate of 0.005 PPTT. A mass gathering that attracts older patrons is more likely to have an elevated incidence of cardiac arrest because of pre-existing medical conditions.

Treatment Categories

Minor care was provided most frequently at baseball games, whereas football and concerts required more basic care. This difference reflects the recording bias discussed above. Minor and basic care combined was provided for 84.1% of the total number of patient visits (2.3 and 2.8 PPTT, respectively), whereas only 15.8% required advanced care (0.97 PPTT). This is similar to overall prehospital systems.

The current study found an advanced-care rate that was higher than previously reported (14%–17%), with concerts being at the higher end. This higher incidence of advanced care, prevalent in the current study, was due to how levels of care were defined. Patients were assigned to advanced care if: (1) they were in the first-aid station for >15 minutes; and (2) arrival/departure times were not recorded, then based on whether ALS or BLS procedures were used. If a patient was in the first-aid station <15 minutes, but ALS procedures were used, then the patient was assigned to advanced care. Without a doubt, there were first-aid patients needing only BLS procedures who were held longer than 15 minutes for various reasons: (1) a high volume of patients with limited staffing caused back-ups and delays, and there were more complicated patients requiring longer treatment times (e.g., BLS treatment of an abrasion, but oral hydration was needed for heat exhaustion). Furthermore, some disposition decisions were complicated

	All Events		Baseball		Football		Rock Concerts	
	n	(%)	n	(%)	n	(%)	n	(%)
Number	5,899	(100.0)	3,659	(62.0)	1,204	(20.4)	1,036	(17.6)
Med Request	583	(9.8)	169	(4.6)	380	(3.1)	27	(2.6)
Bandage Request	32	(0.5)	0	(0.0)	7	(0.6)	16	(1.5)
Dermal Injury	42	(0.7)	27	(0.7)	7	(0.6)	8	(0.8)
Eye Injury	3	(0.05)	1	(0.0)	0	(0.0)	2	(0.2)
Foreign Body	51	(0.8)	44	(1.2)	7	(0.6)	0	(0.0)
CHI	7	(0.1)	2	(0.1)	2	(0.2)	3	(0.3)
Insect Bites	1	(0.01)	0	(0.0)	0	(0.0)	0	(0.0)
Musculoskeletal	51	(0.8)	21	(0.6)	8	(0.7)	22	(2.1)
Other Trauma	6	(0.6)	0	(0.0)	1	(0.1)	5	(0.5)
Abdominal Pain	4	(0.07)	2	(0.1)	2	(0.2)	0	(0.0)
Alcohol/Drug	28	(0.5)	10	(0.3)	8	(0.7)	10	(0.9)
Cardiac Arrest	0	(0.0)	0	(0.0)	0	(0.0)	0	(0.0)
Chest Pain	5	(0.08)	5	(0.1)	0	(0.0)	0	(0.0)
Dehydration	32	(0.5)	10	(0.3)	7	(0.6)	15	(1.4)
Diabetes	8	(0.1)	4	(0.1)	3	(0.3)	1	(0.1)
Dizziness	21	(0.3)	15	(0.4)	0	(0.0)	6	(0.6)
Epistaxsis	1	(0.0)	0	(0.0)	0	(0.0)	1	(0.1)
GI Complaints	29	(0.5)	15	(0.4)	6	(0.5)	7	(0.7)
Headache	22	(0.3)	7	(0.2)	4	(0.3)	11	(1.0)
Heat Exhaustion	48	(0.8)	12	(0.3)	7	(0.6)	29	(2.8)
Heat Stroke	0	(0.0)	0	(0.0)	0	(0.0)	0	(0.0)
Hypothermia	0	(0.0)	0	(0.0)	0	(0.0)	0	(0.0)
Hyper/Hypotension	23	(0.3)	10	(0.3)	12	(1.0)	1	(0.1)
OB/GYN	8	(0.1)	4	(0.1)	4	(0.4)	0	(0.0)
Other Medical	43	(0.7)	27	(0.7)	7	(0.6)	9	(0.9)
Resp. Distress	9	(0.1)	5	(0.1)	2	(0.2)	2	(0.2)
Seizure	9	(0.1)	3	(0.1)	2	(0.2)	4	(0.4)
Syncope	32	(0.5)	9	(0.2)	5	(0.4)	18	(1.7)
Altered LOC	18	(0.3)	1	(0.3)	3	(0.3)	14	(1.3)
Stabbing	0	(0.0)	0	(0.0)	0	(0.0)	0	(0.0)
None	4,834	(81.0)	3,251	(89.0)	723	(60.0)	824	(79.0)
No Record	5	(0.08)	4	(0.1)	0	(0.0)	1	(0.1)

Table 6—Case-mix by secondary diagnosis

	All Events		Baseball		Football		Rock Concerts	
	n	(%)	n	(%)	n	(%)	n	(%)
Total	5,899	(100.0)	3,659	(62.0)	1,204	(20.4)	1,036	(17.6)
Treatment								
Minor care	2,265	(35.0)	1,769	(48.3)	264	(21.9)	217	(20.9)
Basic care	2,747	(46)	1,310	(35.8)	765	(63.5)	639	(61.7)
Advanced care	943	(16)	580	(i5.8)	175	(14.5)	180	(17.4)
Disposition								
Treat & Release	4,265	(72)	2,947	(80.5)	837	(69.5)	439	(42.4)
Transport	450	(7.6)	225	(6.1)	79	(6.6)	143	(13.8)
AMA	240	(4.0)	63	(1.7)	44	(3.6)	126	(12.2)
Home	351	(5.9)	217	(5.9)	56	(4.6)	74	(7.1)
Other	127	(2.1)	54	(1 5)	20	(1.7)	53	(5.1)
No record	522	(8.8)	153	(4.2)	168	(14.0)	201	(19.4)

Table 7—Treatment category and disposition by event type

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	All Events		Baseball		Football		Rock Concerts	
	n	(%)	n	(%)	n	(%)	n	(%)
MOI	1,789	(30.3)	1,049	(28.7)	294	(24.4)	446	(43.1)
Mosh pit	75	(4.2)	0	(0.0)	0	(0.0)	75	(16.8)
Missile	40	(2.2)	11	(1.0)	1	(0.3)	28	(6.3)
Crowd surfing	63	(3.5)	0	(0.0)	0	(0.0)	63	(14.1)
Mud sliding	1	(0.05)	0	(0.0)	0	(0.0)	1	(0.22)
Fall or trip	399	(22.3)	295	(28.1)	61	(20.7)	43	(9.6)
Fight	54	(3.0)	13	(1.2)	28	(9.5)	13	(2.9)
Foul ball	291	(16.3)	291	(27.7)	0	(0.0)	0	(0.0)
Other trauma	857	(47.9)	432	(41.2)	203	(69.0)	223	(50.0)
Other medical	7	(0.39)	6	(0.6)	1	(0.3)	0	(0.0)
No record	4,110	(69.7)	2,610	(71.3)	910	(75.6)	590	(56.9)
LOI	1,765	(29.9)	1,048	(28.6)	308	(25.6)	410	(39.6)
Head and Neck	553	(31.3)	302	(28.8)	56	(18.2)	195	(47.6)
Torso	121	(6.8)	63	(6.0)	20	(6.5)	38	(9.3)
Upper Extremities	636	(36.0)	428	(40.8)	149	48.3)	59	(14.4)
Lower Extremities	455	(25.8)	254	(24.2)	83	(26.9)	118	(28.8)
No record	4,134	(70.1)	2,611	(71.4)	896	(74.4)	626	(60.4)
Medication Requested	2,940	(49.8)	2,103	(57.5)	605	(50.2)	232	(22.4)
Analgesic	2,539	(86.3)	1,752	(83.3)	563	(93.0)	224	(96.5)
Antacid	285	(9.7)	259	(12.3)	25	(4.1)	1	(0.43)
Antihistamine	66	(2.2)	52	(2.5)	9	(1.5)	5	(2.1)
Bronchodilator	14	(0.47)	10	(0.47)	3	(0.49)	1	(0.43)
Sun block	0	(0.0)	0	(0.0)	0	(0.0)	0	(0.0)
Other	36	(1.2)	30	(1.4)	5	(0.83)	1	(0.43)
No record	2,959	(50.2)	1,556	(42.5)	599	(49.8)	804	(77.6)
Alcohol or Drug Use	210	(3.6)	35	(1.0)	43	(3.6)	132	(12.7)
Alcohol Use	190	(90.4)	35	(100.0)	42	(97.7)	113	(85.6)
Drug Use	20	(9.5)	0	(0.0)	1	(2.3)	19	(14.4)
No Record	5,689	(96.4)	3,624	(99.0)	1,161	(96.4)	904	(87.3)
Alcohol/Drug PPTT	0.22		0.04		0.25		3.8	

Table 8—Descriptive Statistics (MOI = mechanism of injury; LOI = location of injury; n = number of records with data; 'No record' indicates the number of forms with no data (out of 5,899 total, respectively)

(unaccompanied minors and intoxicated patients) and physician input was necessary.

More advanced and basic care was needed at apparent temperatures >80°F (27°C). Also, at higher temperatures, more advanced care was provided than was minor and basic care combined. Furthermore, there were more heat-related illnesses at apparent temperatures >80°F (27°C). The higher amount of advanced care for heat-related illnesses was due either to the need for intravenous hydration or prolonged (>15 minutes) observation and cooling down after oral hydration.

Disposition

The most common disposition at all events was treat-and-release. Rock concerts had more patients sent directly home as well as those leaving against medical advice, a potential medicolegal issue, especially given the large percentage of minors. Rock concerts also had more alternative dispositions (such as cool down rooms) and transports than did any other event. The concerts were longer events, so patients seen toward the end of the day may have been more inclined to go home rather than return to their seats. Head and neck injuries sustained while crowd surfing or in the mosh pit, often required spinal immobilization, and resulted in a higher transport rate from concerts (4.2 PPTT).

Limitations

The ultimate goal of this study was to help with the mass-gathering planning process. By understanding the variables involved and knowing what medical usage rate to expect, the emergency manager can perform a better needs assessment. Based on the findings of this study, the primary separation for planners would be between sporting events (BB and FB) and RC. Even using this classification scheme, it should be noted that some differences exist between FB and BB.

Of the variables studied, only event type and weather can be used to predict the MUR. The number attending the event is a weak predictor, but larger spectator volumes have the potential to lead to higher patient volumes.

For this information to be useful in a prediction model and practical to event planners, planning grids (Tables 3,12, and 13) were constructed. This study did not examine whether the MURs for event type and weather could be combined to produce one useful number. If this was possible, event-staffing considerations could be modified according to the estimated patient volume. Previously published

	Baseball	Football	Rock Concerts
Number	3,659	1,204	1,036
Mean age	29.1	33.3	20.1
95% CI	28.2,29.9	32.4,34.2	19.6,20.5
Median	26.0	33.0	18.0
Standard deviation	19.6	14.3	6.5
Range	91.0	82.0	46
IQR	30.0	17.0	6.0

Table 9—Age data by event type

Gender	Baseball	Football	Sporting Events	Rock Concerts	RC Location A	RC Location B
Number	3,659	1,204	4,863	1,036	207	829
Female MUR (%)	1,770 2.31 (48)	515 3.01 (43)	2,285 2.44 (47)	654 19.05 (63)	99 3.69 (48)	555 74.00 (67)
Male MUR (%)	1,884 2.46 (51)	686 4.01 (57)	2,570 2.74 (53)	361 10.51 (35)	91 3.39 (44)	269 35.87 (32)
No record MUR (%)	0 0.006 (0.1)	0 0.017 (0.2)	0 0.008 (0.2)	21 0.61 (2)	17 0.63 (8)	0 0.66 (0.60)

Table 10—Gender data by event type. Each box contains the raw number of patients treated by gender, the MUR for that gender (listed as PPTT) and the percentage represented by that gender. For example: MUR (555/75,000 x 10,000 = 74.0); Percentage (555/829 = 67%). All events: 2,949 females; 2,980 males; 26 no record

Age Range (years)	Baseball	Football	Sporting Events	Rock Concerts	RC Location A	RC Location B
Number	3,659	1,204	4,863	1,036	207	829
Attendance	7,655,507	1,709,743	9,365,249	343,318	268,318	75,000
No record MUR (PPTT) (%)	1,800 2.35 (49)	272 1.59 (23)	2,072 2.21 (43)	295 8.59 (28)	64 2.38 (31)	231 30.8 (28)
<21 MUR (PPTT) (%)	766 1.00 (21)	163 0.95 (14)	929 0.99 (19)	521 15.17 (50)	44 1.64 (21)	477 63.6 (57)
21-30 MUR (PPTT) (%)	292 0.38 (8)	230 1.34 (19)	522 0.56 (11)	157 4.57 (15)	62 2.31 (30)	95 12.67 (11)
31-40 MUR (PPTT) (%)	302 0.39 (8)	293 1.71 (24)	595 0.63 (12)	50 1.46 (5)	27 1.01 (13)	23 3.07 (4)
41-50 MUR (PPTT) (%)	226 0.29 (6)	149 0.87 (12)	375 0.40 (8)	0 0.23 (0.7)	0 0.19 (2)	0 0.40 (3)
>50 MUR PPTT) (%)	273 0.36 (7)	97 0.57 (8)	370 0.39 (8)	0 0.14 (0.5)	0 0.19 (2)	0 0 (0)

Table 11—Age data listed by event type. Each box contains the raw number of patients treated in that age range, the MUR for that age range (listed as PPTT) and the percentage represented by that age. For example: MUR (477/75,000 x 10,000= 63.6 PPTT); percentage (477/829 x 100 = 57%)

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	All Events	Sporting Events (Baseball+Football)	Baseball games	Football games	Rock Concerts
Case Mix					
Medication request	2.3	2.2	2.3	1.5	6.4
Dermal injuries	0.76	0.65	0.55	1.1	3.7
Musculoskeletal injuries	0.97	0.73	0.73	0.77	6.7
Head injuries	0.04	0.02	0.01	0.04	0.76
Eye injuries	0.10	0.09	0.10	0.06	0.38
Epistaxsis	0.06	0.03	0.03	0.03	0.81
Headache	0.47	0.43	0.16	1.6	1.4
Chest pain	0.05	0.05	0.05	0.09	0
Cardiac arrest	0.005	0.005	0.005	0.006	0
Syncope	0.06	0.06	0.05	0.10	0.29
Seizure	0.02	0.02	0.02	0.02	0.11
Heat illnesses	0.47	0.29	0.27	0.36	5.2
Abdominal/GI illnesses	0.18	0.17	0.18	0.15	0.29
Insect bites	0.05	0.04	0.03	0.09	0.35
Respiratory eases	0.09	0.06	0.04	0.12	0.87
OB/GYN	0.03	0.03	0.01	0.09	0.09
Alcohol/drug cases	0.08	0.02	0.01	0.07	1.7
Other medical cases	0.20	0.19	0.14	0.40	0.49
Trauma-related	1.9	1.5	1.4	1.9	12.6
Medical-related	4.2	3.7	3.4	5.1	17.5
Treatment Categories					
Minor care	2.3	2.2	2.3	1.5	6.3
Basic care	2.8	2.2	1.7	4.5	18.6
Advanced care	0.97	0.81	0.76	1.0	5.2
Patient Dispositions					
Treat & release	4.4	4.0	3.8	4.9	12.8
Transport	0.46	0.32	0.29	0.46	4.2
AMA	0.25	0.11	0.08	0.26	3.7
Home	0.36	0.29	0.28	0.33	2.1
Other	0.13	0.08	0.07	0.12	1.5

Table 12—Planning Table. Each cell represents a rate in terms of PPTT (patients per 10,000 attendees). The numbers in each case mix cell were calculated by dividing the primary diagnosis by the total attendance, then multiplying by 10,000. PPTT rates for traumatic/medical diagnosis, dispositions, and treatment categories were calculated using only the primary diagnosis. Heat illnesses = dizziness, dehydration, heat exhaustion and heat stroke combined

staffing models then would be used to assist with staffing decisions in association with planning guides.[2,3,92]

There are limits to using the MUR for planning and predicting injury patterns in general.[5] First, attendance estimates are unreliable, unless the event occurs at a site with fixed seating. Attendance can be estimated from previous event ticket sales as well as actual numbers of people at an event.[9,42] Second, the statistical testing in this study was limited to three event types with several dependent variables. Third, exceptions will occur, because many variables cannot be fully accounted for or studied. Fourth, definitions of minor/basic/advanced care are not standardized within the literature, which can lead to confusion relative to the levels of care provided. Furthermore, since no standard diagnostic coding has been established to categorize injuries, investigators tend to tally the same disease in different ways

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Case Mix	All Events	Sporting Events (Baseball+Football)	Baseball Games	Football Games	Rock Concerts
Medication Request	2.9	2.8	2.5	3.8	7.2
Dermal Injuries	0.81	0.68	0.59	1.1	3.9
Musculoskeletal Injuries	1.0	0.76	0.75	0.82	7.3
Head Injuries	0.07	0.03	0.02	0.07	1.2
Eye Injuries	0.10	0.09	0.09	0.06	0.44
Epistaxsis	0.06	0.03	0.03	0.03	0.84
Headache	0.49	0.44	0.17	1.7	1.7
Chest Pain	0.06	0.06	0.05	0.09	0
Cardiac Arrest	0.005	0.005	0.005	0.006	0
Syncope	0.10	0.07	0.06	0.12	0.81
Seizure	0.03	0.02	0.02	0.03	0.23
Heat Illnesses	0.57	0.34	0.26	0.43	6.7
Abdominal and GI Illness	0.21	0.20	0.20	0.19	0.49
Insect Bites	0.05	0.04	0.03	0.09	0.35
Respiratory Cases	0.10	0.07	0.05	0.13	0.93
OB/GYN	0.04	0.04	0.02	0.12	0.09
Alcohol/drug Cases	0.11	0.04	0.02	0.12	2.0
Other Medical Cases	0.24	0.22	0.17	0.44	0.75

Table 13—Planning Table. Primary and secondary diagnoses combined. Each cell represents a rate in terms of PPTT (patients per 10,000 attendees). The numbers in each ease mix cell of table 13 were calculated by combining the primary and secondary diagnosis. PPTT rates for traumatic/medical diagnosis, dispositions, and treatment categories were calculated using only the primary diagnosis. Heat illnesses = dizziness, dehydration, heat exhaustion and heat stroke combined

(i.e., head injuries in this study included patients with closed head injuries and those with non-medically related altered level of consciousness). Finally, what the event promoters or sponsors want (with respect to medical coverage), may not match consistently the information your pre-event resource planning generates. Those with the money and the ability to award contracts may have the last say in what resources they want at a mass gathering event.

This study suffers from several important additional limitations. Documentation was another problem area. Consistently recording all relevant patient information (including arrival and departure times) was an issue, especially during busy mass gatherings. Recording bias was present in this study with regards to medication request forms. Short, easy to use forms with buy-in from the first-aid station staff are essential for good record keeping.

Conclusions

What the emergency planner should take away from this study has been reported in two ways. Results were reported as the percentage of the total number of patients contacted at a particular event. Knowing the expected case mix that likely will be present at a certain event should be helpful in preparation for an event at which the attendance is known. Results also were reported as MUR (PPTT), a number that may be more useful for planners. A planner can multiply these rates by the estimated attendance and obtain a useful number of anticipated patient flow in medical-aid stations.

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