ORIGINAL RESEARCH

Validation of a Modified Medical Resource Model for Mass Gatherings

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Abbreviations:
ALS: advanced life support
BLS: basic life support
EMS: emergency medical services
FIFA: Fédération Internationale de Football Association
ILS: intermediate life support
PPR: patient presentation rate

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Abstract

Introduction: A modified Medical Resource Model to predict the medical resources required at mass gatherings based on the risk profile of events has been developed. This study was undertaken to validate this tool using data from events held in both a developed and a developing country.

Methods: A retrospective study was conducted utilizing prospectively gathered data from individual events at Old Trafford Stadium in Manchester, United Kingdom, and Ellis Park Stadium, Johannesburg, South Africa. Both stadia are similar in design and spectator capacity. Data for Professional Football as well as Rugby League and Rugby Union (respectively) matches were used for the study. The medical resources predicted for the events were determined by entering the risk profile of each of the events into the Medical Resource Model. A recently developed South African tool was used to predetermine medical staffing for mass gatherings. For the study, the medical resources actually required to deal with the patient load for events within the control sample from the two stadia were compared with the number of needed resources predicted by the Medical Resource Model when that tool was applied retrospectively to the study events. The comparison was used to determine if the newly developed tool was either over- or under-predicting the resource requirements.

Results: In the case of Ellis Park, the model under-predicted the basic life support (BLS) requirement for 1.5% of the events in the data set. Mean over-prediction was 209.1 minutes for BLS availability. Old Trafford displayed no events for which the Medical Resource Model would have under-predicted. The mean over-prediction of BLS availability for Old Trafford was 671.6 minutes. The intermediate life support (ILS) requirement for Ellis Park was under-predicted for seven of the total 66 events (10.6% of the events), all of which had one factor in common, that being relatively low spectator attendance numbers. Modelling for ILS at Old Trafford did not under-predict for any events. The ILS requirements showed a mean over-prediction of 161.4 minutes ILS availability for Ellis Park compared with 425.2 minutes for Old Trafford. Of the events held at Ellis Park, the Medical Resource Model under-predicted the ambulance requirement in 4.5% of the events. For Old Trafford events, the under-prediction was higher: 7.5% of cases.

Conclusion: The medical resources that are deployed at a mass gathering should best match the requirement for patient care at a particular event. An important consideration for any model is that it does not continually under-predict the resources required in relation to the actual requirement. With the exception of a specific subset of events at Ellis Park, the rate of under-prediction for this model was acceptable.

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Introduction

The level and amount of staffing required at mass gatherings remains controversial, and decisions as to staff requirements (number and category) often are based more on past experience than on evidence-based modelling.[1,2] Where models do exist, they may be too resource intensive for settings in the developing world.

A modified Medical Resource Model for the resource-constrained mass gathering environment recently has been described.[3] The Model uses an event profile and other pre- determined characteristics to predict the numbers and qualifications of medical staff necessary to provide standardized medical coverage at events held in developing countries. Examples of factors taken into account in the Model are nature of the event, expected

number of spectators, and seasonal considerations.[3] Points are allocated according to the event profile categories and medical resource requirements predicted according to a standard matrix. The derivation of this Model has been described previously but it has not been validated.[3] The purpose of this study was to validate the Medical Resource Model during mass gatherings hosted in both a developed and a developing country.

Methods

Study Design

This study was a retrospective analysis of single-event and pooled data utilizing prospectively gathered event medical data from two sports stadia. The study was designed to validate the Medical Resource Model, which was developed to determine the level and amount of staffing required at mass gatherings. This medical staffing prediction model was used during the 2010 Fédération Internationale de Football Association (FIFA) World Cup matches. The stadia selected for the study were Old Trafford Stadium in Manchester, United Kingdom, and Ellis Park in Johannesburg, South Africa. Both stadia host large and varied sporting and entertainment events in an open-air environment, and are similar in size and design. Emergency medical data for actual responses collected by medical personnel on site during events at both stadia were used as control data and for comparisons to the medical staffing predictions using the Medical Resource Model for the same events. For this study, Rugby Union, Rugby League, and Professional Football event data were selected and analyzed.

Old Trafford Stadium in Manchester, United Kingdom, is the 68,000-seat home ground for the Manchester United Football (soccer) Team. While predominantly used to host football matches, the stadium also plays host to Rugby League games. Ellis Park Stadium in Johannesburg, South Africa, is a 55,000-seat stadium that hosts both Professional Football as well as Rugby Union matches. Data from both venues and all three sports (Rugby League, Rugby Union, and Football) were included in the study. The study was approved by the Ethics Committee of the University of Cape Town.

Data Collection

Old Trafford—Data obtained from Old Trafford was collected by the medical teams providing standby at the stadium, from August 2000 to August 2006. A total of 105 soccer or rugby events were hosted during this period. Of these, 12 were excluded from the study as attendance figures were not available.

Attendance figures were obtained from match reports and were cross-referenced.[4,5] Total gate attendance for the 93 events included in this study was 6,061,890. Clinical data were recorded for each patient evaluated at any of the events. Clinical data included both the diagnosis and the severity of the complaint as well as the final disposal—released back into the crowd or transported to hospital.

Ellis Park—Data were collected from Ellis Park by a single sports physician providing the medical care during all events held at the stadium during the period from January 2004 to May 2007. No data were available for the year 2005 due to a computer theft. A total of 66 events were included in the study, representing Rugby Union and Football. Attendance figures were obtained from the Ellis Park Management Team and totalled 1,224,024 for the 66 matches.

Clinical data included both the diagnosis and the disposal of the patients, following assessment by a member of the medical team. Data were entered into a spreadsheet in Microsoft Excel 2007 version 12 (Microsoft Corporation, Redmond, Washington USA). Data were processed using SPSS version 14.0 (IBM Corporation, Armonk, New York USA).

Data Processing

Determination of Medical Resources Required—Data regarding the number, severity, and nature of the medical complaints were reviewed. The nature of the medical condition was reviewed in terms of the treatment required. In turn, this information was correlated to the scope of practice for EMS practitioners who operate in South Africa under license of the Health Professions Council of South Africa.

The patients were assigned into one of three categories determined by their presenting complaint and subsequent treatment requirement(s):

1. *Minor*—medical condition that could be treated within the scope of practice of a BLS provider in South Africa;
2. *Moderate*—condition that required treatment and intervention falling within the scope of practice of a South African ILS provider; or
3. *Severe*—condition that required stabilization and immediate ambulance transfer to the closest appropriate hospital.

Time was selected as the common denominator to relate the numbers of patients that presented per severity category to the required medical resources. As no formal standards exist, an informal process was followed to determine recommended patient contact times for BLS, ILS, and advanced life support (ALS). The opinions of EMS experts in the United Kingdom, the United States of America, and South Africa were sought regarding the patient contact time deemed realistic when dealing with basic, intermediate and advanced life support conditions. Using the times derived from the expert survey, a mean time was calculated for each contact time: BLS, ILS, and ALS.

With these expected patient contact times, it was possible to convert the numbers of patients seen per severity code to the number of minutes required in total to see all of the patients who presented. In line with the definition, if an event produced one "severe" coded patient then one ambulance would be required to transport the patient to a hospital. For the purpose of the study, when an ambulance transported to a hospital it was deemed lost to the event.

Determination of Medical Resources Predicted—Medical resources predicted for the study events were determined by entering the risk profile of each event into the Medical Resource Model. The resultant number of predicted resources was converted into the total amount of time available per level of care. To calculate this availability time, it was necessary to determine the total time that the medical resources would be available at the event.

The events described by the data set are of three sporting codes that have a total match time of no more than two hours. A further two hours were allocated to ensure that the pre-match as well as the post-match periods received medical coverage. Thus, a total of four hours was utilized as the time that medical resources would be present at each of the events.

If the Model predicted that 12 BLS practitioners would be required at an event, then the total BLS time available for that

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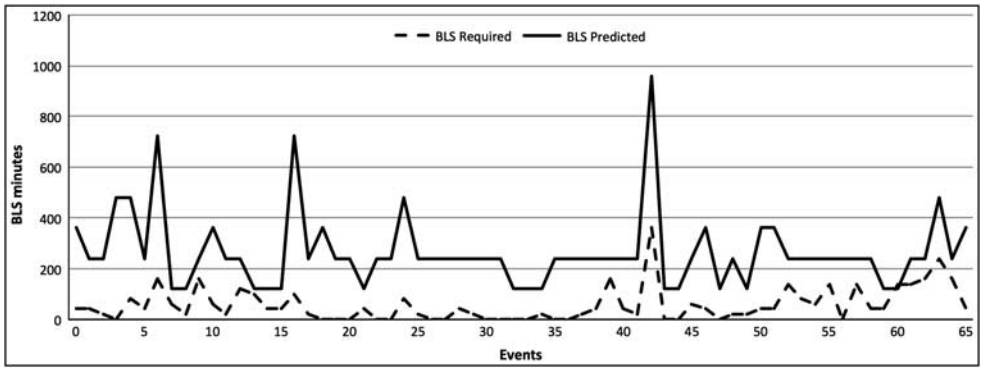

Figure 1. Basic Life Support (BLS) Required vs. BLS Predicted—Ellis Park

Stadium	Mean	Median	SD	Range	Minimum	Maximum	Count
Ellis Park	209.1	210	128.62	640	-20	620	66
Old Trafford	671.6	700	207.87	980	20	1,000	93

Table 1. Basic Life Support Descriptive Statistics

event would be 2,880 minutes (12 practitioners x 4 h x 60 min). As these events occurred in a stadium, the medical teams would be deployed in order to ensure that medical care was well-distributed throughout the stadium. Medical planning in a stadium commonly sees the stadium divided into four distinct zones for the purpose of command and control. In this situation, then, 720 minutes of BLS time would be available per zone, assuming the resources are distributed equally.

Model Prediction

Evaluation of the Medical Resource Model was carried out by comparing the medical resources that were required to deal with the patient load for the events within the research sample with the number of resources that the model predicted should be deployed using the risk data for the specific events.

Results

Patient Contact Time

The patient contact time utilized in this study was 15 minutes for BLS and 25 and 30 minutes for ILS and ALS, respectively. A further five minutes were added to each category for response time to the patient. In this manner, BLS responses and patient contact time would be 20 minutes, with ILS and ALS being 30 and 35 minutes.

As an example, an event that produced six minor and three moderate patients would require 120 (6 x 20) minutes of BLS time and 90 (3 x 30) minutes of ILS time, allowing also for response times of five minutes.

Research Sample

The total number of patients evaluated was 1,714. These patients were those who were attended to by medical personnel who staffed either of the stadia. The patients were classified into "Mild," "Moderate," and "Severe" categories depending upon their condition and the treatment they required. Of the 1,448 patients seen at Old Trafford, 1,227 (85%) were classified as "Mild," 138 (10%) as "Moderate," and 83 (6%) as "Severe." In the case of Ellis Park, a total of 266 patients were seen with 186 (70%) being "Mild," 61 (23%) "Moderate," and 19 (7%) "Severe."

Basic Life Support—The comparison between BLS required and BLS predicted is diagrammed in Figure 1 as it applies to Ellis Park, with the descriptive statistics in Table 1.

The model under-predicted the BLS requirement for one Ellis Park event. This represents an under-prediction rate of 1.5% of the studied Ellis Park events. The mean over-prediction was 209.1 minutes for BLS availability, which represents a 373% mean over-prediction.

Old Trafford displayed no events for which the Medical Resource Model would have under-predicted (Figure 2). The mean over-prediction in the case of Old Trafford was 671.61 minutes BLS availability, which equates to a 252% over-prediction. Descriptive statistics for the BLS comparison are listed in Table 1.

Intermediate Life Support—Actual required and Model-predicted ILS resource deployment for Ellis Park is shown in Figure 3. For this data group, the model under-predicted for seven of the total of 66 events (10.6% of the events). Upon review of the data, it was noted that the events in which the model under-predicted all had the common factor of relatively low spectator attendance numbers. Ellis Park events are described in Table 2. ILS modelling for Old Trafford is shown in Figure 4. In the Old Trafford data set with an average spectator attendance of 65,182, no event was under-predicted.

The descriptive statistics of the ILS comparison are listed in Table 3 and show a mean over-prediction of 161.36 minutes ILS availability for Ellis Park (582% over-prediction) compared with 425.16 minutes for Old Trafford representing an over-prediction of 965%.

Ambulance Requirements—The number of ambulances required for events held at Ellis Park plotted against the predicted

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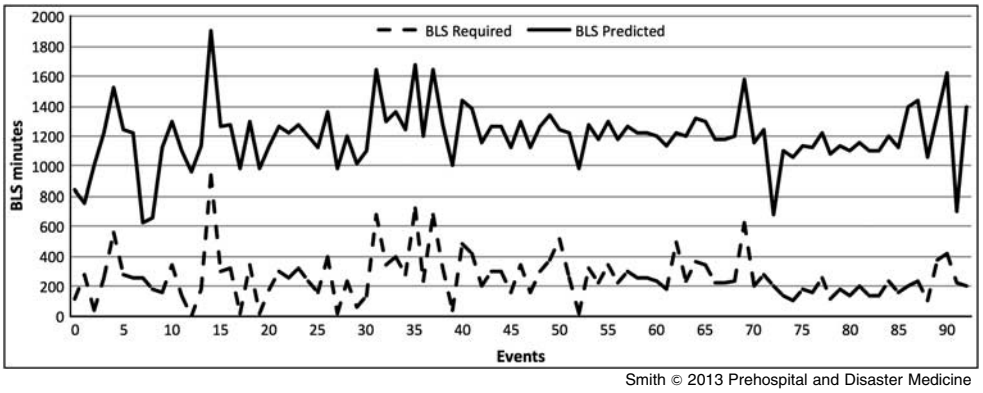

Figure 2. Basic Life Support (BLS) Required vs. BLS Predicted—Old Trafford

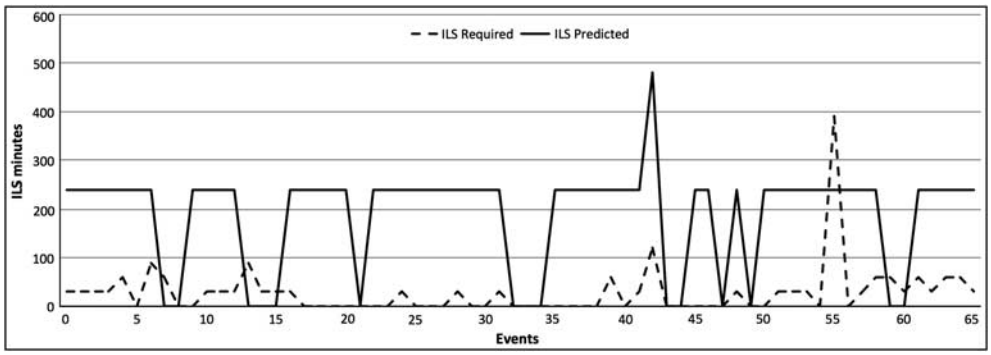

Figure 3. Intermediate Life Support (ILS) Required vs. ILS Predicted—Ellis Park

Date	Spectator Numbers	ILS Required (min)	ILS Predicted (min)
July 5, 2003	7,597	60	0
October 5, 2003	5,187	90	0
October 11, 2003	7,762	30	0
October 25, 2003	4,892	30	0
April 28, 2006	11,500	390	240
February 10, 2007	7,519	60	0
February 17, 2007	8,512	30	0

Table 2. Under-Prediction for Intermediate Life Support (ILS) in Relation to Spectator Numbers

requirement is shown in Figure 5. Of the Ellis Park events, the Medical Resource Model under-predicted the ambulance requirement for three of 66 events (4.5%). In the case of the events held at Old Trafford, the under-prediction was higher. For Old Trafford, the Medical Resource Model under-predicted the ambulance requirement for seven of the 93 events (7.5%). The number of ambulances required compared with the number of ambulances predicted is shown in Figure 6.

Discussion

Quality of Data

The data collected represents a total of 159 events held at either Old Trafford or Ellis Park. All data were collected prospectively by the same group of physicians at their respective stadia. Consistency in the persons collecting the data should ensure that the data was accurate. Despite this data collection consistency, data originated from two different stadia. It is, therefore, not easy to make direct comparisons as stadium variability may occur. Such variability may exist in terms of the standard operating procedures as well as the differences that may exist in the scope of practice of the medical personnel deployed.

Patient Severity

The findings of this study are consistent with previous studies of mass gatherings, in that most of the medical presentations required minor medical intervention.[6-8] At Ellis Park, 70% of

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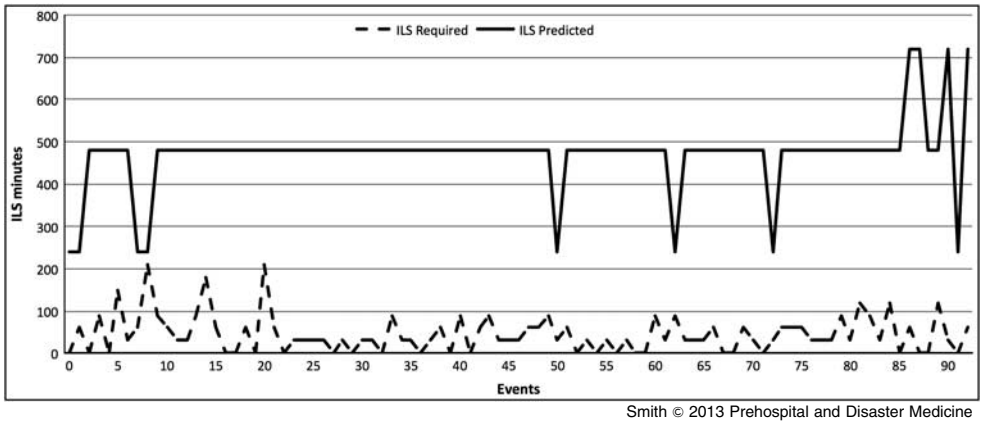

Figure 4. Intermediate Life Support (ILS) Required vs. ILS Predicted—Old Trafford

Stadium	Mean	Median	SD	Range	Minimum	Maximum	Count
Ellis Park	161.36	210	113.08	510	-150	360	66
Old Trafford	425.16	450	101.02	690	30	720	93

Table 3. Intermediate Life Support Descriptive Statistics

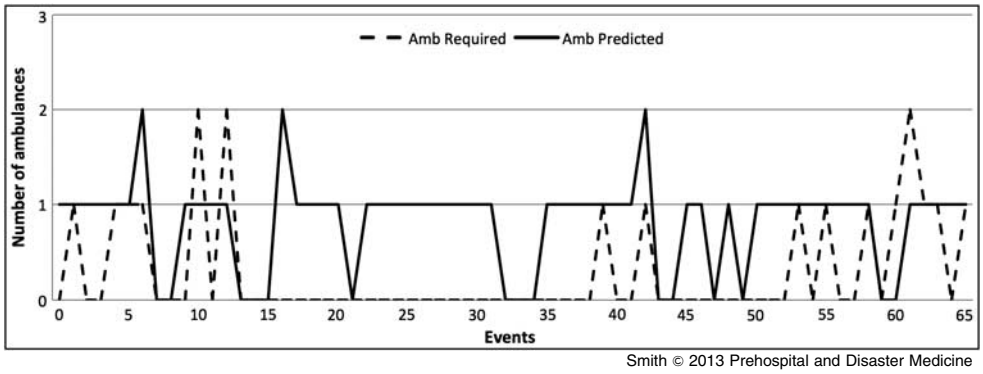

Figure 5. Ambulances Predicted vs. Ambulances Required—Ellis Park

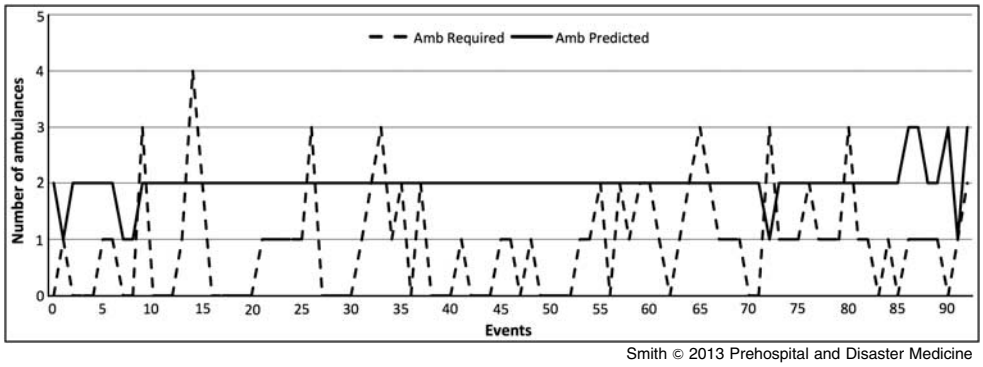

Figure 6. Ambulances Predicted vs. Ambulances Required—Old Trafford

the patient presentations were classified as minor compared with 85% at Old Trafford. This dominance of minor ailments highlights the importance of having suitable numbers of first aid providers or basic life support practitioners present at mass gatherings. These personnel should be well-distributed throughout the crowd to provide a visible presence for persons requiring medical assistance. As the first line of response, providers of first aid or BLS can access patients rapidly and make required assessments, with requests for further medical support if required.

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Evaluation of the Medical Resource Model

As described previously, the aim of this study was to determine if the Medical Resource Model can effectively predict the number of medical personnel required for a mass gathering.

Due to the various factors that influence the mass gathering patient presentation rate (PPR), the effectiveness of the Model is difficult to prove statistically. It also was not the intent of this study to test the impact of these various factors on PPR.

What was deemed important was to review the Model in terms of the number of events for which it under-predicts the medical resources required at the events. The number of medical personnel required as determined by using the historical data was compared with the requirement predicted by the Model. The following paragraphs describe comparisons of the three levels of medical care studied.

Basic Life Support—For Ellis Park, the model under-predicted the BLS requirement in 1.5% of the events. Additional BLS availability should not be considered a luxury, as it allows for rotation and relief of personnel, and ensures that enough personnel are available to respond should more than one event occur simultaneously. In the case of Old Trafford, no events were under-predicted for BLS requirements.

Medical staff at mass gatherings have two primary functions: (1) to provide rapid medical care for individual patients who may have suffered an injury or illness while attending the event; and (2) to perform a vital role in preparedness and planning for major incidents, not only by their presence at the event, but also due to their familiarity with the environment. What the ideal number of practitioners should be to deal with both of these functions is speculative. The number of patients that may result from a major incident is unpredictable and medical planning for medical emergencies is likely to be a hit-and-miss affair. The study model seems to be sufficiently effective in predicting BLS requirement. It allows for additional BLS practitioners, which would not be wasted resources in the case of a major incident.

Intermediate Life Support—The Model resulted in an under-prediction for ILS availability in 10.6% of the events held at Ellis Park. In all cases, the under-prediction occurred during events that had low spectator numbers. In most cases, attendance was <10,000. The Model performed better when the events had larger numbers of spectators. Clearly, this is evident in the Old Trafford data set where the mean attendance number per event is 65,182. None of the Old Trafford events were under-predicted in terms of ILS availability and the mean of over-prediction was 425.2 minutes compared with Ellis Park's mean over-prediction of 161.36 minutes. Due to the low sample size, it is not possible to statistically determine the significance of this observation of under-prediction at low attendance numbers. The Model performs satisfactorily, in that it does not under-predict ILS availability except in the subset of events with low attendance numbers.

Ambulance Availability—In this study, the number of ambulances required per event was related to the number of patients whose conditions were classified as severe. Under-prediction for ambulances occurred in 4.5% of the 66 events held at Ellis Park, whereas Old Trafford's data displayed a 7.5% under-prediction.

While under-prediction for ambulances occurred in a limited number of cases, it should be considered that the assumption was made that should an ambulance transport a patient to a hospital, it would be lost to the event. This is unlikely to be a true reflection of reality because when the hospital is close to the event, the ambulance is likely to complete its mission and return to the event. The concept of another ambulance being summoned to replace the one that left was not considered a viable alternative in the modelling. Such a replacement ambulance in all likelihood would need to be sourced from the operational fleet serving the population at large, thus going against one of the fundamental reasons for developing a medical resource model which is to provide medical coverage at mass gatherings without impact on the daily activity of Emergency Medical Services. In South Africa, due to poor EMS response times, ambulances are dedicated to events because of the risk that response time would be unacceptably high should one be called to an emergency at an event.

Other Medical Resources

The modified Medical Resource Model includes other care providers in addition to those described above. While the aim of this study was to review the effectiveness of the model in predicting the requirement for BLS, ILS, and ambulances at mass gatherings, mention should be made of the other resources it predicts. The presence of a medical coordinator is proposed for all events that score in excess of 36 points on the matrix. This is to ensure the efficient command and control of the relatively large number of medical persons who would be deployed at such an event. The medical coordinator takes no part in clinical activity at the event and thus was not included in this study.

The model also proposes the number of ALS practitioners, doctors, and nurses that should be deployed at some events. It proposes that all events scoring ≥31 should have an ALS-qualified professional on site, whereas doctors should be deployed at events scoring ≥41 points. The roles of these two categories of medical personnel are clinical supervision and stabilization of the critically injured or ill patient. The assumption made in this study was that all severe patients were transported to a hospital, and as such, the doctor and ALS data from the two stadia were not included in the study. It is accepted, however, that severe patients would be stabilized by either the doctor and or ALS practitioner prior to transportation if deemed necessary.

The model recommends that one or more nurses be present at events with a score >46. The role of the nurse is to assist at the venue medical center as well as to provide nonemergency health care. For the 2010 FIFA World Cup, nurses were deployed as proposed in the Medical Resource Model. In regard to other mass gatherings, it is unlikely that scarce nurse resources would be available for deployment.

Limitations

The model is proposed as the standard for all mass gatherings in South Africa. However, this study has used data only from events representing three sporting codes (Rugby Union, Rugby League, and soccer). Although there was consistency in the collection of data at each of the two stadia, the data used in this study were not collected from a single source, but rather from two separate entities. To develop a norm for the patient contact time, a survey was done by canvassing expert opinions worldwide. This was not done by means of a traditional Delphi study. Certain assumptions were made in developing the time available per treatment code. One such assumption is that medical

coverage per event took place over a period of four hours. The exact length of time will vary from event to event. Another assumption made was that an ambulance tasked with transporting a patient to a hospital would be lost to the event. This is unlikely in reality, and therefore, should underestimate ambulance availability on site.

Conclusions

The medical resources deployed at a mass gathering should best match the requirement for patient care at the event. Each event is different, with its own risk profile. Therefore, it is unlikely that the number of medical staff deployed will exactly match the requirement. An important consideration for any model is that it does not continually under-predict the resources required in relation to the actual need.

This study showed that the mass gathering study model has an acceptably low under-predication rate, occurring exclusively at those events with low attendance. While over-prediction may not be acceptable to event organizers due to the additional costs involved, it does allow for flexibility within the event health care delivery system. More importantly, it allows for additional medical resources to be in attendance on site to deal with any major incidents that may occur.

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