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A NEW SCORE TO IMPROVE RESOURCE ALLOCATION DURING MASS GATHERING EVENTS

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ABSTRACT

Mass gathering events (MGEs) place a strain on public health systems and require careful planning of healthcare resource allocation, including ambulances and personnel. The Maurer's algorithm is commonly used to determine resource allocation, taking into account event type, location, participants, and potential public order issues. A working group from the Italian Regional Emergency and Urgency Agency (AREU) analyzed critical aspects of Maurer's algorithm and developed the G.A.M.E.S. algorithm (Management Assistance for Sporting Events). The G.A.M.E.S. algorithm optimizes health care resource planning for MGEs and addresses the shortcomings of Maurer's algorithm. Compared to Maurer, G.A.M.E.S. shows improved accuracy, especially for smaller events. Standardized event categorization and sports event prioritization improve resource allocation. The G.A.M.E.S. algorithm is a useful tool for predicting resource needs, especially for small and medium-sized events. Prospective validation studies are essential to assess its applicability across a wider range of contexts.

Introduction

A mass gathering event (MGE), as defined by the World Health Organization (WHO), is an organized or unplanned event in which the number of people attending is sufficient to strain the community's planning and response resources. (1) This definition does not include the size of the population attending the event, as each system or community has different crowd management capabilities. Examples of MGEs include sporting events, concerts or music festivals, public exhibitions, political demonstrations, and religious pilgrimages.

Given the number of people who attend MGEs, special attention should be paid to public health prevention when organizing such events. Several public health risks may affect people attending an MGE, and these risks may be either predictable or unexpected. Health services are designed to respond to daily demands but may not always be able to cope with a sudden increase if they are not well prepared in advance, given the limited resources available. To avoid excessive burden on health systems during an MGE, it is essential to carefully assess all potential health risks, predict patient volumes, and plan resource needs accordingly.

For example, the patient presentation rate during an MGE depends on several aspects of the event itself, such as whether it is held outdoors or in an unrestricted venue, the lack of free water, the lack of air conditioning, the nature of the event, and the presence of alcohol. (2,3) Despite preparations, something unexpected may happen; therefore, it is essential to critically analyze the health resources actually needed at an MGE in order to optimize medical preparedness for similar events in the future. (4,5)

Required healthcare resources may include equipped medical personnel, first-aid and medical assistance points, ambulances, and personnel dedicated to the transport of patients to the designated hospital.

In the Italian region of Lombardy, the Regional Emergency and Urgency Agency (AREU) is responsible for ensuring pre-hospital emergency care, as well as monitoring and managing the pre-hospital emergency network and the European 112 emergency telephone service throughout the region, in compliance with national legislation. (6) Moreover, the Lombardy Region has entrust-

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ed AREU with the task of validating medical services for sporting events and other planned public gatherings. For this purpose, AREU developed the online portal G.A.M.E.S. (Management Assistance for Sporting Events) to manage authorization requests and provide event organizers with a database of approved rescue associations. Furthermore, the information shared on the portal by the parties involved enables effective coordination of healthcare assistance in the event of emergencies during events. (7)-

Few tools are available to help plan for healthcare needs during MGEs. These include the Patient Presentation Rate (PPR) and Transport to Hospital Rate (TTHR) models, although they have poor predictive performance and generalizability. (8)

Another available tool is the Maurer's algorithm, which quantifies the human resource needs of emergency services. It was developed in 2003 by Klaus Maurer, Chief of the Hamburg Fire Brigade, to assess the healthcare resources required for planned events. The algorithm quickly gained significant popularity worldwide and is still in use today. (3,5)

AREU employed Maurer's algorithm for events held between 2015 and 2020, finding low accuracy in predicting healthcare resource requirements for nearly all events under consideration. It therefore became evident that the algorithm needed to be significantly modified to better meet the needs of our region.

Materials and Methods

Emergency medical system in Lombardy (Italy)

In Lombardy, the AREU oversees the pre-hospital emergency system, coordinating rescue operations through ground vehicles and helicopters. In the event of a medical emergency, citizens dial the European emergency number, 112, and their call is received by a trained operator. The operator collects essential information, assesses the severity of the situation, and assigns a priority code to ensure the optimal use of resources and vehicles. Regional dispatch centers then manage the logistics, selecting the most appropriate rescue unit and identifying the most suitable hospital for the patient based on the nature and seriousness of the incident. There are several types of ground vehicles available, each with a different professional team. Depending on the assessed needs, the dispatch center may deploy a vehicle manned by trained volunteers, an advanced unit equipped with a nurse, or a vehicle with both a nurse and a physician.

Working group

A working group of AREU members specializing in public health and emergency medicine studied and critically analyzed Maurer's algorithm. The group carried out a structured reasoning process to identify the algorithm's intrinsic limitations when applied to the specific regional context. During this process, the experts identified several key issues, including the systematic overestimation of resources for small-scale events, the inflexibility in accounting for event type heterogeneity, and the limited adaptability to AREU's organizational and operational framework. These recurring limitations, identified through professional experience and critical discussion, emphasized the need to develop a new scoring system to optimize the allocation of medical resources during MGEs. Following an evaluation of the limitations of the Maurer's algorithm, the G.A.M.E.S. algorithm was developed to address the critical issues identified.

Results

In accordance with the purpose of this article, we compared the G.A.M.E.S. algorithm with Maurer's algorithm. The two formulas for evaluating resources are compared below.

Maurer's algorithm takes into consideration several parameters of the event by using the formula:

$$R = \{[A + (B*Z)] \times C\} + D + E$$

A attributes points based on the maximal capacity of the venue; B is attributed based on the forecasted number of participants; Z coefficient is based on whether the event is held indoor (Z=2) or outdoor (Z=1); C points are attributed according to the type of the event; D depends on the number of public personalities attending the event; E express the potential public order issues of the event.

The developed G.A.M.E.S. algorithm formula is a modified version of Maurer's algorithm, expressed by the formula:

$$R = [(A/500) + (B*K) \times Z] \times C + D + E$$

A is the maximum number of participants allowed in the venue, regardless of whether the event is indoor or outdoor; K is introduced as a crowding coefficient based on the percentage of venue capacity to be occupied; C, B, Z, D, and E express the same parameters as in Maurer's formula.

The result of the Maurer or G.A.M.E.S. algorithm (R score) is used to determine the number of ambulances needed to support the event.

AREU revised the allocation of basic life support (BLS) ambulances corresponding to the obtained result (R score), as detailed in Table 1.

Discussion

During our experience with the application of Maurer's algorithm, several critical aspects emerged.

We observed a disproportionate weight placed on indoor locations; during event processing, indoor musical events received higher scores than outdoor events, despite having an inherently higher risk of injury for participants, such as in motorcycle races.

Another critical issue observed is the algorithm's inability to accurately detect discrepancies between the venue's capacity and the actual number of attendees. This issue occurs both when the venue is overcrowded and when the attendee count is substantially below the stated capacity, leading to the deployment of either too few or too many BLS ambulances and, consequently, resource misallocation.

Moreover, the classification of event types identified by Maurer's algorithm's C-variable score proved to be redundant in some cases and lacking in others; for example, religious events, which are common in our region, weren't included in the provided list. For this reason, AREU made several changes to the event categories. One valuable aspect of our approach is the division of sports events, acknowledging the substantial variation in potential injury or harm across different sports.

Maurer originally designed his tool to assess large-scale MGEs, whereas most events evaluated by our agency were of moderate to low magnitude. Consequently, for such events, the number of BLS ambulances required by Maurer's algorithm exceeded the actual needs. For this reason, we revised the allocation of BLS vehicles for each R score, as shown in Table 1.

Table 1. Ranges of R scores with the corresponding number of required BLS ambulances.

	Number of BLS	
Score	**Maurer's algorithm**	**G.A.M.E.S. algorithm**
0.1-1	1	0
1.1-6		1
6.1-12	4	2
12.1-20		3
20.1-25.5		4
25.6-45.5	6	6
45.6-60	8	8
60.1-75.5	9	9
75.6-100	11	11
>100	14	14

BLS, basic life support.

The developed algorithm sets a common standard for event planning. In this way, in case of a major emergency, it will be possible to determine whether the event organizers have ensured adequate standards. This is a crucial aspect, especially since the tool proposed by the Lombardy Region in accordance with national law is Maurer's algorithm. (6) Using a scoring system to evaluate resource utilization during MGEs can also be highly beneficial in training for disasters and mass casualty incidents, where tailored simulations are often employed to improve the preparedness of healthcare personnel. (9-11)

The G.A.M.E.S. algorithm has been in operation for several years, during which the allocated healthcare resources for each event have always been sufficient. However, there was no analysis of the possibility of overestimating resources. A prospective observational study or an analysis of past events would be beneficial to determine whether the G.A.M.E.S. algorithm meets the requirements. National policies may have a strong impact on the resource allocation during emergencies; therefore, a careful evaluation of this tool would be required before a broader application. (12)

Conclusions

Establishing a common standard for assessing low- and medium-risk events is critical to determining the minimum healthcare resources needed to ensure attendee safety. Such assessments are becoming increasingly important, especially in light of the shortage of healthcare professionals that several countries are experiencing, as resource employment needs to be carefully planned. In addition, given the critical role of expertise in managing emergencies, assessing the qualifications of professionals working at sporting events is also essential.

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