Disaster Medicine and Public Health Preparedness

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Concepts in Disaster Medicine

Cite this article: Paleari A, Spina S, Marrazzo F, *et al*. How the Italian formula 1 grand prix 2022 mass gathering event compares to the Arbon model: A descriptive study. *Disaster Med Public Health Prep*. **17**(e468), 1–5. doi: https://doi.org/10.1017/dmp.2023.122.

Keywords:
Formula 1; EMS; mass gathering event; patient presentation rate; Arbon Model

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How the Italian Formula 1 Grand Prix 2022 Mass Gathering Event Compares to the Arbon Model: A Descriptive Study

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Abstract

Objective: To describe the health-care resources implemented during the Italian Formula 1 Grand Prix (F1GP) and to calculate the patient presentation rate (PPR) based on both real data and a prediction model.

Methods: Observational and descriptive study conducted from September 9 to September 11, 2022, during the Italian F1GP hosted in Monza (Italy). Maurer's formula was applied to decide the number and type of health resources to be allocated. Patient presentation rate (PPR) was computed based on real data (PPR_real) and based on the Arbon formula (PPR_est).

Results: Of 336,000 attendees, $n = 263$ requested medical assistance with most of them receiving treatment at the advanced medical post, and $n = 16$ needing transport to the hospital. The PPR_real was 51 for Friday, 78 for Saturday, 134 for Sunday, and 263 when considering the whole event as a single event. The PPR_est resulted in 85 for Friday, 93 for Saturday, 97 for Sunday, and 221 for the total population.

Conclusions: A careful organization of health-care resources could mitigate the impact of the Italian F1GP on local hospital facilities. The Arbon formula is an acceptable model to predict and estimate the number of patients requesting medical assistance, but further investigation needs to be conducted to implement the model and tailor it to broader categories of MGE.

The Italian Formula 1 Grand Prix (F1GP) has been disputed since 1921 and the great majority of its previous editions have been hosted in Monza (Italy), one of the oldest circuits in the world. The last edition of the Italian F1GP (ie, the 92nd) took place from September 9 to September 11, 2022, in Monza, where more than 336,000 attendances have been recorded during the three days. The AREU (Emergency and Urgency Regional Agency) emergency medical services (EMS) managed for the first time the entire medical assistance for the public, racers, and all F1 personnel.

The F1GP can be considered a mass gathering event (MGE), although a unique definition is not reported in the literature. Some Authors consider the lower limit of 1000 people, while others define MGE as an event that involves more than 25,000 participants.[1,2] Regardless of the lack of a straightforward definition, the Italian F1GP can be considered a proper model of MGE, doubling the number of inhabitants of Monza (from approximately 124,000 inhabitants to 336,000 people in its territory).

Over the past two decades, several attempts have been made to predict the number of patients during MGE, such as the F1GP, and to support EMS preparedness.[3] In this regard, the Arbon model is one of the most widely used.[4] The state/territory variable seems to be one of the most important in predicting the patient presentation rate (PPR) during an MGE; however, it is challenging to implement a model with worldwide validity.[5] The current study aims to describe the health-care resources implemented during the Italian F1GP; to calculate the PPR during the most-recent edition of the Italian F1GP, and to test the Arbon model in such a scenario.[4]

Methods

This is an observational and descriptive study conducted from September 9 to September 11, 2022, during the Italian F1GP, where the AREU EMS was in charge of the event health care, along with the substantial support of the emergency medical technician type B (EMT-B) volunteers of the Italian Red Cross, who are trained with 120 h of classroom plus 40 h of clinical

practice and qualified to perform basic life support (BLS) defibrillation. Due to the study's nature and the absence of any identifiable private information, the requirement for institutional review board approval was deemed not necessary.

The AREU manages the EMS in the Lombardy region, covering a population of approximately 10 million people in an area of approximately 24,000 square kilometers, including the Monza e Brianza district. The F1 circuit is immersed in Monza Park, which belongs to the Villa Reale estate. The park is one of the largest in Europe, reaching 700 hectares, conferring to the circuit a unique and challenging environment surrounding the F1 circuit.

The AREU is based on a 2-level public safety answering point (PSAP) system. The primary-level PSAP is the initial recipient of 1-1-2 phone calls from citizens seeking police, fire, or medical assistance. The PSAP-1 re-directs medically-related calls to the medical secondary-level PSAP (PSAP-2) which manages regional EMS resources. PSAP-2 is staffed with 14 technicians (dispatchers), 7 nurses, and 2 physicians (working in teams) who: (1) assess and triage medical emergencies; (2) dispatch ambulances (and other health-care vehicles); and (3) assign the most appropriate hospital destination based on proximity, specific patient needs, bed availability, and operational functioning.[6]

The AREU strengthened its forces during the F1GP, which was one of the largest MGE in Lombardy. As per regional regulations when planning for medical assistance during MGEs, Maurer's formula was applied to decide the number and type of health resources to be allocated considering the type of the event, the estimated number of visitors, and some other additional circumstances (ie, presence of famous people or violent groups).[7] The following variables are included in the model: (1) expected attendance; (2) type of event; (3) frequency of the event; (4) alcohol selling and consumption; (5) possible drugs consumption; (6) presence of weak category of people; (7) large advertisement on mass media; (8) presence of political or religious leaders (ie, a VIP or another person able to attract several peoples to the event due to her/his presence); (9) difficult road conditions; (10) social and political tensions; (11) duration of the event; (12) type of surrounding; (13) type of venue; (14) availability of toilettes; (15) availability of water; (16) availability of refreshment points. Those variables are presented in Table 1, along with variables included in the Arborn formula.

The resources used during the Italian F1GP were divided into two completely independent groups, as per authorities' regulations. The Mauer formula was used solely to plan the resources dedicated to the general public. Instead, the number and kind of resources for the racetrack and drivers was provided by the Fédération Internationale de l'Automobile (FIA). The first group of resources was addressed to the spectators and consisted of:

- Eight BLS ambulances with 2 or 3 EMS technicians each.
- Six on-foot BLS teams with 3 EMS technicians each.
- Two advanced life support (ALS) ambulances with 2 EMS technicians, 1 EMS nurse, and 1 EMS physician each.
- One rescue team on 2 motorbikes, 1 EMS nurse, and 1 EMS physician.
- Five first aid posts with 2 EMS technicians, 1 EMS nurse, and 1 EMS physician.

The second group of resources was addressed only to the racetrack and the drivers and, as established by the FIA, consisted of:

Table 1. List of variables included in Maurer's formula and in the Arborn algorithm

Maurer's formula variables	Arborn algorithm variables
Expected attendance	Expected attendance
Type of event	Is the event fenced/bounded?
Frequency of the event	Does the event take place indoor?
Alcohol selling and consumption	Does the event take place outdoor?
Possible drugs consumption	Is it a sporting event?
Presence of weak categories of people	Level of humidity (%) expected for the day
Large advertisement on mass media	Are attendants seated?
Presence of political or religious leaders	Product expected attendance * humidity %
Difficult road conditions	Does the event take place both day and night?
Social and political tensions	
Duration of the event	
Type of surrounding	
Type of venue	
Availability of toilets	
Availability of water	
Availability of refreshment points	

- Six BLS ambulances.
- Three ALS ambulances.
- One FIA medical car with a physician rescue coordinator.
- Three fast medical cars with 1 EMS technician, 1 EMS nurse, and 1 EMS physician.
- Three extrication teams with 4 EMS technicians, 1 EMS nurse, and 1 EMS physician all licensed in vehicle extrication procedures.

An advanced medical post was also established inside the circuit with the following personnel: 2 EMS physicians, 4 EMS nurses, 1 trauma surgeon, 1 orthopedic surgeon, 1 neurosurgeon, 1 radiologist, 1 radiology technician, and other technicians for logistical support. Moreover, 2 intensive care unit beds were kept available throughout the 3 days of the event at San Gerardo Hospital (Monza, Italy), the closest trauma center. The resources were managed by 2 EMT-B (dispatcher technicians) and 1 EMS dispatcher nurse in a control room inside the medical center. Figure 1 reports the distribution of health-care resources within and outside the F1 racetrack according to the results provided by Maurer's formula.

Statistical Analysis

Data were collected through a regionally-developed software for computer-aided dispatch (Emma, version 6.8.5, Beta80 Group S.P.A., Milan, Italy) and exported using SAS Web Report Studio 4.4 M4 (SAS Institute Inc., Cary, NC). The descriptive analysis was performed with Microsoft Excel (Microsoft Corporation, Redmond, WA). The Arbon formula is based on the following equation[4]:

$$Y = b0+(b1*C1)+(b2*C2)+(b3*C3)+(b4*C4)+(b5*C5)+(b6*C)+(b7*C7)+(b8*C8)+(b9*C9)$$

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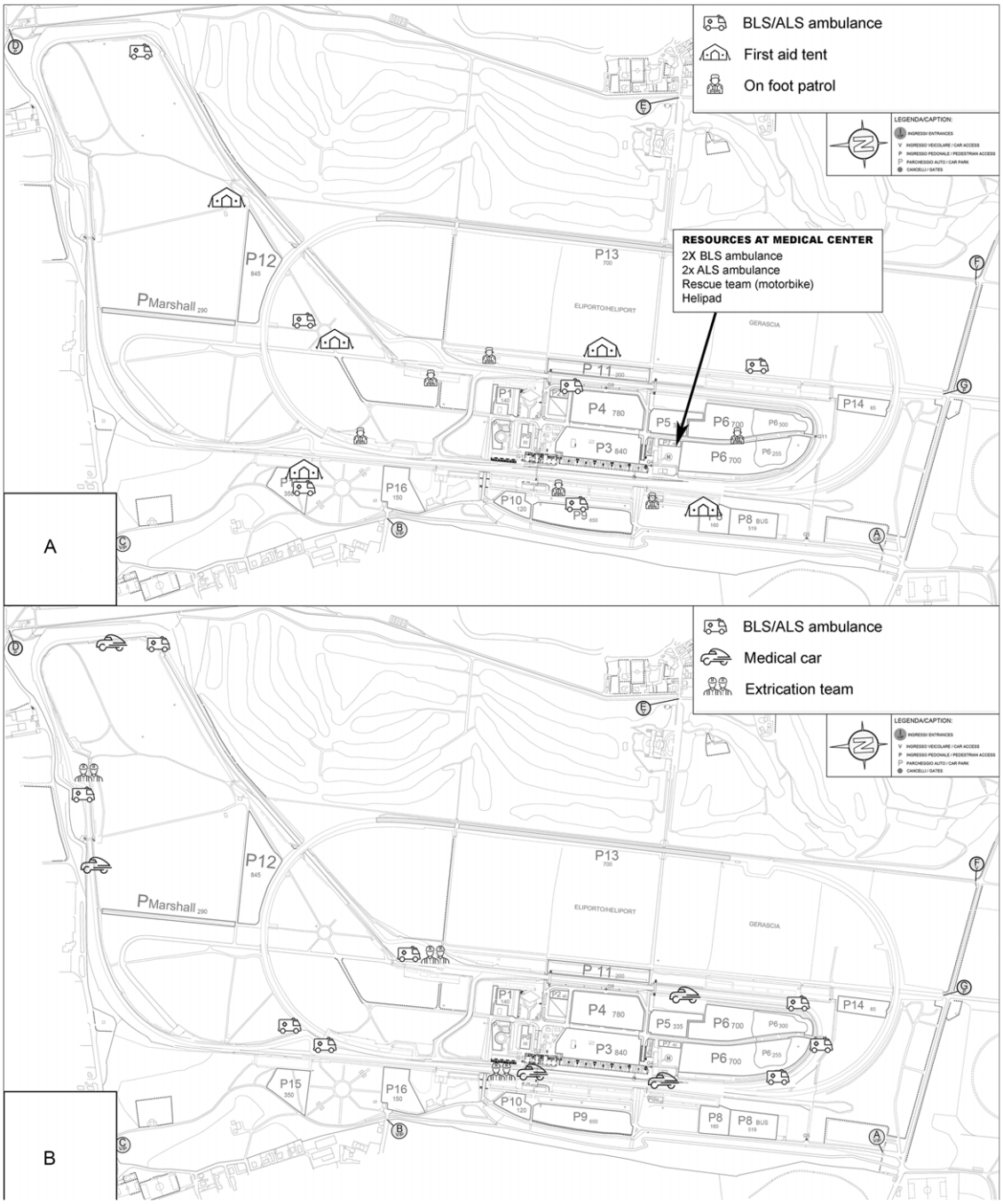

Figure 1. Location of the resources implemented for medical assistance. A: Resources inside the racetrack dedicated to pilots. B: Resources for the general public.

where Y represents the number of estimated PPR, values "b" represents the independent variables obtained by Arbon et al. with a linear regression model,[5] and values "c" are dependent variables. Variables c1-c2-c3-c4-c5-c9 are Boolean type variables, which assume value 1 when true and 0 when false as follows:

c1) SEATS = Are attendants seated?
c2) BOUNDED = Is the event fenced/bounded?
c3) INDOOR = Does the event take place indoors?
c4) OUTDOOR = Does the event take place outdoors?
c5) SPORTS = Is it a sporting event?
c6) HUMID = Level of humidity (%) expected for the day.
c7) ATTEND = Number of persons expected to attend the event.
c8) ATTHUMID = Product ATTEND * HUMID.
c9) DAY-NIGHT = Does the event takes place both day and night?

To test the Arbon model on a larger population, we also considered the total number of attendants as a single-day event. For this purpose, we considered the humid_index as the mean between the values from the 3 different days. According to Serwylo, a patient is described as an individual seeking medical assistance in any form (eg, by calling 1-1-2 or self-presenting to first aid posts).[5] Based on this definition we calculated the PPR as the number of

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Table 2. Details about dispatches, daily variables, and patients' presentation rate (PPR) throughout the different days of the event

No. of dispatches					
Type of resource	Friday	Saturday	Sunday	Total	Mean ± SD
BLS ambulance, *n*	25	41	80	146	48.66 ± 28.3
On-foot patrol, *n*	2	2	8	12	4 ± 3.5
Rescue team, *n*	5	4	5	14	4.67 ± 0.6
Cancelled request, *n*	2	4	8	14	4.67 ± 3.1
Total, *n*	34	51	101	186	62 ± 34.8
Daily variables					
Humid_index	67.00	64	59		63.33 ± 4
Attendants, *n*	93000	111000	132000	336000	112,000 ± 19,519.2
PPR_est	85.24	93.96	97.28	221.16	91.86 ± 6.1
PPR_real	51	78	134	263	87.67 ± 42.3

Note: Details about dispatches, daily variables, and PPR throughout the different days of the event.
Abbreviations: BLS, basic life support; Humid_index, humidity index; PPR, patient presentation rate; PPR_est, PPR estimated with Arbon model; PPR_real, PPR real; SD, standard deviation.

patients per 1,000 attendants. A simple linear regression model was implemented, with real PPR value (PPR_real) as continuous predictor and estimated PPR (PPR_est), as continuous outcome. R-squared was also computed. A $P < 0.05$ was deemed statistically significant. Statistical analysis was performed using GraphPad Prism (version 9.5.1, GraphPad Software, San Diego, CA) and STATA (version 13.0, StataCorp, TX).

Results

According to the company that manages the Monza F1 circuit, 93,000 attendants were present on Friday, 111,000 on Saturday, and 132,000 on Sunday (a total of 336,000 people). The mean temperature was 23°C (min 16 - max 28) on Friday, 22°C on Saturday (16-27), and 23°C on Sunday (16-28).

During the 3 days of the F1GP, a total of 263 attendees requested medical assistance with most of them receiving treatment at the advanced medical post and only 16 (6.1%) ultimately needing transport to the hospital. Of those, 126 patients presented with a traumatic injury, and the remaining 137 subjects complained of nontraumatic injuries. Overall, during the 3 days, BLS vehicles were dispatched 146 times, on-foot teams were dispatched 12 times, and the rescue team was dispatched 14 times. Considering BLS ambulance dispatch, the mean number of interventions (each BLS per day) was 4 on Friday, 6 on Saturday, and 10 on Sunday. Of note, 14 attendees withdrew the request for assistance. Data are shown in Table 2.

Of note, 83.5% of assistance requests were granted only by BLS ambulances, and 7.6% of requests were managed by on-foot teams; both of them were composed solely of EMT-B personnel. The rescue team (critical care doctor and nurse) was dispatched in 8.9% of cases. Most patients were completely treated inside the circuit, in the first aid posts, or inside the medical center.

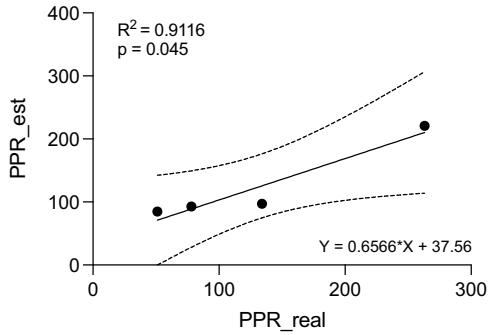

Figure 2. Simple linear regression model. In the bottom right, the regression equation is reported. PPR_est, patient presentation rate estimated; PPR_real, patient presentation rate real; *P*, *P*-value; R^2, R squared.

The real PPR value (PPR_real) was calculated based on the aforementioned data, as compared with the estimated PPR (PPR_est) obtained from the Arbon model. Both values are presented in Table 2, along with the humidity index and the attendant's number, which are the 2 variables of the Arbon formula changing over the 3 days. The PPR_real was 51 for Friday, 78 for Saturday, 134 for Sunday, and 263 when considering the whole event as a single event. The PPR_est resulted in 84.84 for Friday, 92.66 for Saturday, 97.28 for Sunday, and 220.76 for the total population. Simple linear regression was used to test if PPR_est significantly predicted PPR_real. The fitted regression model was: PPR_est = 37.5 + 0.66*PPR_real. The overall regression was statistically significant ($R^2 = 0.91$; $P = 0.045$). Figure 2 reports the linear regression model.

Discussion

In this brief report, we described the medical assistance implemented during the most-recent edition of the Italian F1GP. We also compared the PPR values, based on actual data and expected data, provided by the Arbon prediction model, and confirmed that such a model grants a good estimate of PPR.

When compared with a larger study that described a similar event (ie, F1GP in Singapore), we obtained comparable results regarding the type of disease leading the patients to request medical assistance.[8] Despite the peak of intervention on Sunday, which was strongly related to the higher number of attendances, the number and the type of resources implemented could be considered adequate due to the almost negligible impact on the local hospitals. The daily average of patients admitted to the emergency department of San Gerardo Hospital (the referral hospital of Monza and the entire district) by EMS service is 36. Despite the city of Monza doubled its population due to the F1GP, only 16 patients were transported to the hospitals in the 3 days. With the management of deployed resources, we obtained similar results as compared to other MGE that took place in Italy and were reported in the literature.[9,10]

The Arbon model was developed based on regression analysis with respect to environmental and event characteristics. According to some authors, the algorithm tends to underestimate the PPR.[3] In our case, the PPR_est was overestimated on Friday and Saturday. However, it was underestimated on Sunday and when considering the event's 3 days as a unique model. This might suggest that the algorithm tends to overestimate the PPR for a smaller number of attendants, which is indeed underestimated for larger crowds.

https://doi.org/10.1017/dmp.2023.122 Published online by Cambridge University Press

Moreover, among the 3 different days of the event, the only 2 variables that changed were attendance rate and humidity index (that combines the effects of air temperature and humidity, considered as a representation of weather conditions). Daily humidity indexes are shown in Table 2. Arbon showed a linear relationship between the humidity index and PPR.[4] However, other environmental factors impacted the PPR, considering that 47.9% of patients requested medical assistance for traumatic injuries. The Italian F1 racetrack is inside a park with large areas of uneven ground and a huge presence of bugs (in particular bees and wasps) that may partially explain this large number of traumas. This could be considered as a limitation of the Arborn model that does not contain any variable to describe the type of ground of the venue.

Limitations

As the Arbon formula was applied only to a single event, the study is not powered enough to provide any validation of the Arbon model. Moreover, a high degree of variability exists not only among the individuals participating in an MGE but also between different types of MGEs; thus, any model that predicts PPR should be carefully tailored to the specific setting in order to assist the planning of the medical services.

Conclusions

A careful organization of health-care resources could mitigate the impact of an MGE, such as the F1GP, on local hospital facilities. In this setting, the Arbon formula is an acceptable model to predict and estimate the number of patients requesting medical assistance and to assist in planning. However, further investigation needs to be conducted to implement the model and tailor it to broader categories of MGE.

Acknowledgments. The authors are deeply grateful to all the technicians, nurses, and physicians working in the emergency medical system in Lombardy (Italy).

Author contribution. A.P. and S.S. contributed equally to this manuscript. A.P., S.S., R.S., R.F. contributed to the study concept and design. A.P. and R.S. contributed to data acquisition. A.P., S.S., and F.M. contributed to the initial drafting of the manuscript. All authors contributed to data interpretation and critical revision of the manuscript. S.S., R.S., and R.F. contributed to study supervision. F.M., S.S., and A.R. contributed to the discussion of the results and reviewed the data and the final manuscript. All authors had full access to all the data in the study and had final responsibility for the decision to submit for publication.

Funding. The authors declare no financial support for this manuscript.

Competing interests. The authors declare no conflict of interest.

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