Injury investigation and emergency medical care experience in mass gatherings: A case study of the 13th National Games of China

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Abstract: Objectives: To acquire the disease rules and characters of the athletes, analyze the influencing factors of traumatic injury. Methods: Five hundred ten valid cases from July 2017 to September 2017 were classified according to the International Classification of Diseases (ICD-10); a binary logistic regression model was performed to analyse the influencing factors of traumatic injury. Results: Among the 14 disease classifications, traumatic injuries accounted for the largest number, with significant differences by sex, competition venue, and competition event (P<0.05). Sex and competition events were risk factors for traumatic injury (OR>1). In particular, athletes participating in ball games were more likely to experience traumatic injury than those participating in nonball games. Conclusions: It is necessary to implement differentiated allocation of medical resources for different competition events, achieve a balance between supply and demand; take intervention measures to reduce risk factors. This can be a basis for subsequent mass gatherings in the context of the COVID-19 epidemic and disease prevention through establishing an emergency medical security system.

Keywords: Emergency medical security system; Mass gatherings; COVID-19; Binary logistic regression; traumatic injury; Public health

1. Introduction

The COVID-19 pandemic represents an unprecedented challenge for policymakers, the medical and research communities, and the wider public around the world, all of whom have rightly focused on the deaths caused by the virus[1]. Globally, the COVID-19 cases have risen for the sixth consecutive week, with over 4 million new cases reported in the last week. The number of new deaths also increased by 11% compared to last week, with over 71,000 new deaths reported[2]. As of 24:00 on April 8, 2021, there were a total of 279 active COVID-19 cases in China, with 4,636 deaths and 85,471 recovered cases[3]. The prevention and control of the COVID-19 epidemic in China have been further consolidated, and prevention and control
work has shifted from a state of emergency to normal operations. However, epidemics poses a huge threat to global public health epidemics and continues to spread overseas, and the occurrence and rebound risks of locally clustered epidemics cannot be ignored.

Mass gatherings are common in human social life. The World Health Organization defines them as crowds of a certain size coming to the same place in a planned or spontaneous way, leading to the emergence of infectious diseases and creating challenges for the prevention and control of these diseases \([4]\). For example, large sporting events, Carnival, the Olympic Games, and religious activities dominated by pilgrimages are all mass gatherings. Mass gatherings cause congestion in local traffic and communication, and in cases of emergency, can extend the health response time \([5]\).

Sports meets are typical examples of mass gatherings and include events such as the upcoming Tokyo Olympics in Japan and the 14th National Games of China. The National Games of the People's Republic of China is a comprehensive event and has the largest scale, the highest competitive level and the strongest radiation-driven effect of any games held in China. The 13th National Games was held in Tianjin from August to September 2017. This National Games had 47 venues, 33 major competitions, and 417 minor competitions, including dragon boats and martial arts, football, basketball, and shooting. The number of athletes participating in the competition reached 10,200, constituting a mass gathering. The large number of participants, the complexity and risk of the competition and other uncontrollable factors led participants to have an increased demand for medical assistance. The medical and health department of the organizing committee comprehensively coordinated the medical service resources of the city, established an emergency medical security system covering the venues, the entire Olympic Village and the reception hotels, and confirmed 36 designated medical institutions to provide comprehensive medical services for the Games. In addition, the Tianjin Centers for Disease Control and Prevention, the Institute of Health Supervision and other departments acted to fully safeguard public health at the venues and in the residential areas.

Mass gatherings are associated with major public health challenges \([6]\). Viral reproduction and host adaptation occur faster than usual during mass gatherings. The efficient spread of infection and drug-resistant organisms is expedited by this rapid mass movement and mixing of infectious and susceptible populations \([4]\). The travel ban following the COVID-19 outbreak delayed the spread of the novel coronavirus (SARS-CoV-2) from Wuhan to other cities by 2.91 days \([7]\). Thus, mass gatherings play an important role in the spread of epidemics. How can health care be provided for a large number of people during mass gatherings? The Global Mass Gatherings Medical Center was established in Saudi Arabia and combines academic institutions and medical institutions with complementary professions around the world to provide reasonable public health policies and suggestions for the organizers of mass gatherings \([8]\).

At present, the global epidemic situation is still severe, and the situation in China is sporadic. This is a serious challenge for the upcoming 14th National Games of China and the Olympic Games to be held in Japan. Previous research has not discussed how to provide medical protection during mass gatherings in the context of the COVID-19 epidemic. This article retrospectively discusses the emergency medical security situation, analysis the status of patients presenting and being transferred to hospitals during the National Games, the factors
influencing disease, proposes effective intervention measures, makes recommendations for how to reduce morbidity and fatality rates and how to establish an emergency medical security system for mass gatherings in the context of the COVID-19 epidemic. It provides a reference for the organization of the 14th National Games of China, the Tokyo Olympic Games, the 2022 Winter Olympic Games and similar mass gatherings around the world.

2. Materials and Methods

2.1 Data collection

The data in this article are derived from the primary data provided by the Health Emergency Office of the Tianjin Health Commission. The data include the name, age, sex, identity, date of visit, competition event, preliminary diagnosis, treatment results and other basic personal information of the injured and sick. The source of the information is factual and reliable. Ethical approval was obtained from Tianjin University Ethics Committee (TJUE-2021-116—approved 10 June 2021).

2.2 Research methods

A total of 593 cases were collected for this article, 83 cases with incomplete medical record data were excluded, and 510 effective cases were ultimately included. A total of 510 valid cases were classified by professional coders with a medical background (MD) according to the disease diagnosis method in the International Classification of Diseases (ICD-10). If the same patient suffered from two or more diseases, the main diagnosis was used for the analysis. The data collation and summary were checked by two people to ensure the accuracy of the data analysis.

With the aid of SPSS 22.0 software, the binary logistic regression method was used to analyse the influencing factors of traumatic injury, and descriptive statistical analysis was performed for the competition events and disease types.

3. Results

3.1 The rules and characters of diseases

The patient presentation rate (PPR) and transfer to hospital rate (TTHR) differed by the competition event. Thirty-three events in total were selected as main events. According to the research data, the marathon event had the highest PPR, and the women’s water polo had the lowest PPR. The five events with the highest PPRs were the marathon, modern pentathlon, basketball, tennis, and badminton competitions, as shown in figure 1. The marathon event also ranked first in terms of TTHR, followed by football, basketball, tennis, and badminton. The figure 1 shows that the PPR and TTHR of the marathon event were significantly different from those of the other events. This is because in marathons, the main running-related injuries (RRIs) are sudden sports deaths and traumatic injury, and traumatic injury mainly manifests as musculoskeletal disease.
Among the recovered effective cases, 510 effective cases involving athletes were selected and coded according to the International Classification of Diseases (ICD-10) based on 14 disease codes (figure 2). The results show that traumatic injuries were the most common, affecting a total of 157 patients, and respiratory diseases were ranked second, affecting a total of 152 patients. These were followed by digestive system diseases and skin and subcutaneous tissue diseases, mental and behavioural disorders, and endocrine diseases. The number of cases of other diseases was relatively small.

3.2 The factors influencing traumatic injury
Using binary logistic regression to analyse the factors influencing athletes' health condition, it was found that sex, competition venue and competition event were the main factors affecting traumatic injury. With traumatic injury as the dependent variable (Y) and sex, age, competition event, and venue as the independent variables (X), a binary logistic regression model was established after assigning values to the variables. The forward stepwise selection method (Forward: LR) was used for variable screening. After 4 iterations of the stepwise regression, all the variables except age were included in the model. The Hosmer-Lemeshow goodness-of-fit test yielded a P value of 0.73, far above 0.05, indicating that there was no significant difference between the model and the saturated model and no need to introduce new variables. Thus, the binary logistic regression model had good explanatory power. The binary logistic regression model can be expressed as:

\[
\ln \left( \frac{p}{1-p} \right) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3
\]

\( P = P (Y \mid X = 1) \): the risk of traumatic injury, \( \beta_0 \): a constant, and \( \beta_i \): the coefficient of the control variable. In the model, \( X_1, X_2, \) and \( X_3 \) represent sex, venue and event, respectively. The prediction results of the binary logistic regression model show that event and sex positively correlated with the dependent variable, and event had the greatest impact on the dependent variable. If the independent variable of event increased by one standard unit, the probability of suffering from traumatic injury increased 0.57 times. The competition venue and the dependent variable were negatively correlated, and if the value of the competition venue variable increased by one unit, the probability of suffering from traumatic injury decreased 0.439 times.

<p>| TABLE 1 Parameter regression results of the binary logistic regression model |
|-----------------------------|----------------|---------|---------|---------|</p>
<table>
<thead>
<tr>
<th>Independent variables</th>
<th>B</th>
<th>Wald</th>
<th>P</th>
<th>OR</th>
<th>95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex(X1)</td>
<td>0.570</td>
<td>8.119</td>
<td>0.004**</td>
<td>1.768</td>
<td>1.195</td>
</tr>
<tr>
<td>Venue(X2)</td>
<td>0.439</td>
<td>4.855</td>
<td>0.028*</td>
<td>0.644</td>
<td>0.436</td>
</tr>
<tr>
<td>Competition event(X3)</td>
<td>0.570</td>
<td>8.059</td>
<td>0.005**</td>
<td>1.768</td>
<td>1.193</td>
</tr>
<tr>
<td>Constant</td>
<td>0.299</td>
<td>0.302</td>
<td>0.582</td>
<td>0.742</td>
<td>-</td>
</tr>
</tbody>
</table>

Note: *: P<0.05; **: P<0.01; ***: P<0.001. Abbreviation: OR, odds ratio.

The regression results for the influencing factors entered into the model are shown in Table 1. The Wald values for competition event, sex and competition venue were 8.059, 8.119 and 4.855, respectively, indicating that sex had the greatest influence on the results. The P values for sex, competition venue and competition event were all less than 0.05, indicating that the differences were statistically significant. The OR values (95% CI) for sex, competition event and competition venue were 1.768 (1.195, 2.617) and 1.768 (1.193, 2.619) and 0.644 (0.436, 0.953), respectively, indicating that sex and competition venue were risk factors and had a promoting effect on the occurrence of external injury; sex and competition event were the main factors affecting the occurrence of traumatic injury.

### 3.3 The emergency medical security system

The medical and health department of the organizing committee comprehensively coordinated the medical service resources of the city and established an emergency medical security system covering the venues, the entire Olympic Village and the reception hotels. According to the comprehensive strengths of the facilities and the need for centres that were nearby and
easily accessible from the events and reception hotel, 36 second tier and above hospitals, Tianjin Emergency Center and Tianjin Blood Center were designated as the medical institutions for the National Games. The 36 medical institutions were distributed across 15 districts in Tianjin, with the exception of Ning He District, and each district had 1-4 designated hospitals that opened a green channel for the National Games and provided comprehensive medical services. Through each designated hospital identifying a liaison, coordinating with the medical department, and selecting medical personnel and with first aid vehicles provided by the Municipal First Aid Center, the Tianjin Centers for Disease Control and Prevention, the Health Supervision Department, the Health Care Department and other departments in each district provided comprehensive safeguarding of public health at the venues and hotels.

**FIGURE 3** Distribution of medical resources in each stage of the opening ceremony

For example, during the opening and closing ceremonies, the distribution of medical resources was as shown in figure 3 and was divided into three main stages: the first stage was during the school rehearsal period, with the school medical offices providing medical security; the second stage was during the on-site rehearsal period, which involved secondary hospitals in Nankai District and Hebei District that sent 1-2 groups of personnel to provide medical protection; and the third stage was during the rehearsal with makeup, when hospitals sent medical staff to provide protection at the designated security hospitals during the opening ceremony.

**TABLE 2** Health resource allocation for each medical station

<table>
<thead>
<tr>
<th>Code</th>
<th>Medical equipment</th>
<th>Number</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Computer</td>
<td>1</td>
<td>With liquid crystal display</td>
</tr>
<tr>
<td>2</td>
<td>Refrigerator</td>
<td>1</td>
<td>With refrigeration and freezing functionality</td>
</tr>
<tr>
<td>3</td>
<td>Stretcher</td>
<td>1</td>
<td>Folding stretcher</td>
</tr>
<tr>
<td>4</td>
<td>Examination bed</td>
<td>1</td>
<td>Simple diagnostic bed for physical examination and simple treatment</td>
</tr>
<tr>
<td>5</td>
<td>Examination table</td>
<td>2</td>
<td>Can be replaced by computer desk or desk</td>
</tr>
<tr>
<td>6</td>
<td>Examination chair</td>
<td>4</td>
<td>Ordinary chair</td>
</tr>
<tr>
<td>7</td>
<td>Waiting chair</td>
<td>6</td>
<td>Three seats per row, two rows in total</td>
</tr>
<tr>
<td>8</td>
<td>Waste bucket</td>
<td>4</td>
<td>Waste bucket</td>
</tr>
<tr>
<td>9</td>
<td>Disposal table</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>
Note: TABLE 2 lists only the basic equipment requirements of the medical stations, and internal adjustments can be made according to the actual situation. In addition, each station needed to be equipped with a tap water pipeline and wash basin.

The medical stations for the 47 National Games venues were completed in accordance with the requirements of the Organizing Committee document "Notice on Printing and Distributing the Guiding Opinions on the Construction Standards of Venues for the Thirteenth National Games". The basic equipment requirements of each medical station are shown in TABLE 2.

<table>
<thead>
<tr>
<th>No.</th>
<th>Item</th>
<th>Quantity</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>Medicine cabinet</td>
<td>1</td>
<td>Can be combined and customized and can also be replaced by independent consoles</td>
</tr>
<tr>
<td>11</td>
<td>Drinking fountain</td>
<td>1</td>
<td>Provides drinkable hot and cold water</td>
</tr>
<tr>
<td>12</td>
<td>Disposable paper cups</td>
<td>1</td>
<td>Environmentally friendly, high temperature resistance</td>
</tr>
<tr>
<td>13</td>
<td>Medical garbage bag</td>
<td>1</td>
<td>Yellow plastic bag with biosafety sign</td>
</tr>
<tr>
<td>14</td>
<td>Folding screen for medical examination</td>
<td>1</td>
<td>2000 mm*1800 mm</td>
</tr>
<tr>
<td>15</td>
<td>Ultraviolet ray lamp car</td>
<td>1</td>
<td>Ozone lamp</td>
</tr>
<tr>
<td>16</td>
<td>Mobile power strip</td>
<td>2</td>
<td>Containing a 3-metre power cord and at least three two-hole and three-hole sockets</td>
</tr>
</tbody>
</table>

FIGURE 4  Medical resource allocation for the whole marathon

According to the results in figure1, marathon events had the highest PPR and TTHR, while badminton events had the lowest PPR and TTHR. Because of the nature of marathons, there is a significant increase in the risk of SCD (sudden cardiac death). Medical security for marathons mainly focuses on the discovery and medical treatment of SCD. Wuqing People's Hospital was the designated hospital for SCD prevention for these games. A total of 30 medical stations equipped with sufficient medical equipment and emergency drugs were set up along the marathon course. A total of 150 medical staff and 12 commanders were selected. The main
configuration is shown in figure 4. Eight doctors and nurses were staffed at the starting and finishing points. The other medical stations were staffed by one doctor and one nurse. A total of 12 ambulance stations were set up throughout the course, with two at the start and finish points, one at each other point, and two motor ambulance stations at the turning point 39 km in. Each ambulance was equipped with a doctor, a nurse, a driver and a stretcher.

4. Discussion

4.1 Differentiate the allocation of medical resources

Due to the different types and risks of injury athletes may experience in different events, different medical resources need to be allocated to achieve a balance between supply and demand. The above statistical results reveal that the PPR and TTHR were highest for the marathon event and lowest for the badminton event. In the context of the National Fitness Program, marathons are proliferating, and the probability of sports injuries and SCD is increasing year by year, which is consistent with Borjesson M's research results [9]. Kang Shukun pointed out that excessively hot temperatures can affect the circulatory system of contestants. Because blood has to flow close to the surface of the skin to help dissipate heat, the return to the heart is slowed, the burden increases, the blood supply to the heart becomes insufficient, and a more rapid heartbeat is required. In maintaining normal functioning, the probability of SCD increases [10].

This National Games is held from July to September. The temperature in Tianjin is high at this time, increasing the possibility of SCD. SCD has a "golden four minutes". Runners must undergo cardiopulmonary resuscitation (CPR) and be treated with an automated external defibrillator (AED) within the first 4 minutes of cardiac arrest. Therefore, during a marathon, in addition to the basic medical resources that other competitions have, a professional cardiologist and an AED are also required. A high-standard and high-quality medical security system is very important to effectively prevent SCD and reduce the mortality rate. The medical resources required for badminton are very different from those needed for a marathon. Jiang Shiying mentioned that in badminton games, medical personnel on the spot should have first aid skills in orthopaedics, trauma and ophthalmology and have the corresponding equipment and drugs [11].

4.2 Take measures to reduce risk factors

Competition events, competition venues and sex are the main factors that cause injury and disease in athletes. Descriptive statistical analysis was conducted on the SPSS results (Table 1). Among 187 patients who were ball game athletes, 39.57% suffered from traumatic injury. In 323 nonball game athletes, 25.70% suffered from traumatic injury. We can infer that among all sports, ball games may have the highest rate of traumatic injury. Regarding the influencing factor of sex, the probability of male athletes being injured was higher than that of female athletes, which is consistent with the views put forward by GD McKechnie. This phenomenon has two main causes. First, male athletes use more intense movements than female athletes, leading to male athletes being far more vulnerable to injury than female athletes. Second, compared with female athletes, male athletes have stronger explosive power but worse flexibility, which greatly increases the possibility of injury [12]. In addition, athletes of different sex
differ significantly in terms of the damaged parts, damage degree and number of injuries. In addition, we also found that among all athletes, the probability of athletes participating in outdoor competitions suffering from traumatic injury (37.62%) was 1.43 times the probability of athletes participating in indoor competitions suffering from traumatic injury (26.3%). This is due to the complex conditions of competition venues for road biking, kayaking, marathons and other events, as well as the influence of uncontrollable factors such as extreme weather, which can greatly increase the likelihood of athletes suffering from traumatic injury.

Therefore, the organizers of events should take precautions. On the one hand, they should reduce the possibility of injury at the source, such as by adding humanized protection measures in the construction of venue facilities. On the other hand, when providing medical security for outdoor competition events, they should focus on resources suitable for treating accidental injuries so that the appropriate drugs and dressing materials can be adequately supplied in cases of trauma and the fatality rate of traumatic patients can be reduced.

It is vital to establish a medical security system for mass gatherings against the background of the COVID-19 epidemic. Medical insurance for mass gatherings abroad is relatively complete. For example, in mass gatherings for religious purposes, approximately 4 million people make a pilgrimage to Mecca in Saudi Arabia every year\(^\text{[13]}\). Some scholars have formulated an effective mass gatherings and safe pilgrimage policy in response to this situation to reduce the incidence of infectious diseases\(^\text{[14]}\). A total of 76,030 staff members participated in the European football championships held in Italy in 2019. The Emergency Management System (EMS) cooperated with local volunteer health care workers to provide medical protection for this event. To enable patients to receive timely treatment, they are deployed in all directions off and on the field. Medical resources include basic life support teams, advanced life support teams, electric bicycles with medical equipment, etc\(^\text{[15]}\). There were 47 competition venues at the 13th National Games, 33 main competition events, and more than 10,000 participants. Such mass gatherings create serious challenges for local health institutions. Emergency management in China and research on mass gatherings are relatively lacking. On the one hand, there are only a few rules and regulations establishing requirements for mass gatherings, but they do not indicate how to provide medical protection in such settings. On the other hand, when an emergency occurs, the emergency agencies of governments at all levels or the relevant health administrative agencies temporarily form a leading medical rescue group responsible for the organization and leadership of medical and health rescue.

At present, the COVID-19 epidemic presents the risk of foreign importation interweaving with sporadic outbreaks of local cases, which poses a serious threat to the upcoming 14th National Games. Increased population density and the mixing of healthy and sick people will have an impact on the spread of infectious diseases and the health of the population. First, on the basis of the basic medical security provided at the previous games, it is necessary to add a digital epidemic prevention and control mechanism, increase the construction of epidemic monitoring and early warning platforms, and implement special management for personnel in high-risk areas to ensure the safety of participants. Then, under the leadership of emergency management and medical experts, it is necessary to establish a robust contingency plan and three mechanisms. The first contingency plan is an emergency plan. Contingency plans should be tailored to the various purposes of different gatherings, and crowd management should be strengthened. For example, in 2014, a lack of crowd management led to a stampede event at
The Bund in Shanghai, resulting in tragedy\textsuperscript{[10]}. The three mechanisms refer to the coordination-communication mechanism, early-warning-response-supervision mechanism, and material preparation mechanism. Second, a professional medical talent team should be established and random emergency skill assessments should be conducted, with the assessment results linked to team members’ usual job performance to achieve the goal of reserving high-quality and high-level medical talent for the national medical security system. Finally, strengthening the combination of peacetime and wartime operations can not only ensure the full utilization and reasonable allocation of resources but also improve the efficiency of emergency rescue.

5. Conclusions

Mass gatherings are very common in human social life. The efficiency of medical rescue depends on the location and environment of the patient, and mass gatherings can extend the health response time. When mass gatherings are held, complex venues and dangerous competition events can increase the possibility of athletes being injured. Therefore, organizers should strengthen the construction of facilities for competition venues, propose intervention measures for risk factors, and establish emergency medical security system for mass gatherings to reduce the possibility of disease. At present, the number of new COVID-19 cases has been increasing globally for six consecutive weeks. The epidemic situation is still grim and sporadic in China. The prevention and control situation is difficult and complex, posing a serious challenge to the upcoming 14th National Games in China and the Tokyo Olympic Games. How to provide a robust medical security system for mass gatherings in the context of the COVID-19 epidemic is a top priority.

Author Contributions:

Conceptualization, S.K.H. and Y.Z.Z.; Data curation, D.T. and L.C.H.; Formal analysis, N.L. and S.B.; Funding acquisition, S.K.H.; Investigation, S.B., D.T.; Methodology, N.L. and L.S.X.; Project administration, Y.Z.Z.; Resources, L.C.H.; Supervision, Y.Z.Z.; Validation, Y.Z.Z.; Visualization, S.B.; Writing—original draft, N.L.; Writing—review & editing, S.K.H. and Y.Z.Z. All authors have read and agreed to the published version of the manuscript.

Institutional Review Board Statement:

The study was conducted according to the guidelines of the Declaration of Helsinki, and approved by the Tianjin University Ethics Committee (TJUE-2021-116—approved 10 June 2021).

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Informed Consent Statement:

Informed consent was obtained from all subjects involved in the study.

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**Data Availability Statement:**

The data presented in this study are available on request from the corresponding author. The data are not publicly available due to the conditions of the ethical approval.

**Conflicts of Interest:**

The authors declare no conflict of interest.

**References**


