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Fatal Retro: A Global Spatiotemporal Analysis of Crowd Crush Disasters in Stadiums (1979–2025)

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Article

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Fatal Retro: A Global Spatiotemporal Analysis of Crowd Crush Disasters in Stadiums (1979–2025)

Dora Edelmann[1]

Abstract

Objective: This study analyzes global patterns of fatal crowd crush accidents (CCA) in stadiums between 1979–2025, focusing on mechanical and dynamical causes.

Methods: A retrospective statistical analysis was conducted using the TBDCA database to examine correlations between facility age, GDP, and event types.

Results: Analysis of 67 tragedies (1,470 victims) shows 88% of fatalities occurred in countries with GDP <$20,000. Most severe cases are linked to "Retro Era" (1950–1990) facilities. While football dominated until 2000, multifunctional use now exceeds 50% of incidents. Lack of inflow control remains a universal risk, especially in Africa. A significant correlation ($\rho = 0.25$, $p < 0.05$) exists between blocked escape routes and mortality. This is the first study to integrate macroeconomic status and "Retro Era" legacy into a global CCA risk model.

Conclusion: The global risk profile of stadium incidents has shifted toward multifunctional use, where the lack of African-style inflow control in low-GDP regions, along with the infrastructural limitations of "Retro Era" stadiums and police negligence at a systemic level, represent the most severe mortality risks.

Keywords: mass event; crowd crush accident; stadium; risk

Introduction

Sports tourism is one of the most dynamic and significant sectors of global tourism [1]. Stadiums are key nodes of the modern urban environment, which have undergone a significant functional transformation since the turn of the millennium [2,3]. While they were previously primarily venues for seasonal sporting events, from the 2000s onwards, multifunctionality became the primary design consideration: today, on a global scale, they host large-scale musical productions, religious events, and political rallies as well (Fig. 1.). This increased utilization and diverse audience composition generate new types of security challenges [4,5], centered around safe spectator placement [6], the management of dynamic crowd movements [7], and integrated planning aligned with smart city concepts [8].

The analysis of incidents from 1979 to the present day confirms that a significant portion of the most severe tragedies is linked to "retro" stadiums of obsolete design built between 1950 and 1980 [9–13]. In these facilities, the lack of pedestrian dynamics simulations [14,15] and the dominant standing-room sectors [16] favored uncontrollable pressure waves [13], while the physical segregation and high fences—representing the security paradigm of the era—functioned as deadly traps instead of escape routes in emergencies.

Processes originating from critical crowd density or the dynamic movement of dense crowds frequently result in fatalities. The concentration of force within a crowd can reach a threshold that induces compressive asphyxia [17–21], while the collective loss of balance can lead to a fatal crowd collapse. Although older literature collectively referred to these events as "stampedes" [22–31], contemporary research distinguishes between various crowd movement phenomena, such as trampling [32], crush [32–34], rush/surge [19], quakes [35], and collapse [29,30,36–44] (collectively: accidents originating from the movement of dense

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crowds, CCA incidents). The physical causes and risk factors of CCAs are extensively and actively researched [29,30,36–43] across diverse analytical perspectives.

Recently, according to Lu et al. [40], the mood of the audience, the presence of vulnerable groups, movement against the crowd (retrograde crowd), deviant individuals, flammable and explosive materials, the design of circulation corridors within the stadium, and critical periods (ingress and egress) are the factors most likely to induce CCA tragedies. The study by Tin et al. [4] draws attention to the significant casualty risks of stadium disasters and the necessity of renovating older facilities.

The present study focuses on the risk factors of CCA accidents occurring in stadiums; alongside conventional factors (e.g., crowd size, economic factors), it introduces as a novelty risk factors arising from the nature of the event, sub-regional characteristics, spatial design [45,46], and crowd dynamics, with particular emphasis on building characteristics.

The study seeks answers to the following research questions:

(1) What common global characteristics can be identified regarding fatal CCAs occurring in sports facilities?

(2) What defines and characterizes various global regions with respect to these accidents?

(3) What specific architectural characteristics define the sites of these accidents?

(4) How do economic development and regional location influence the characteristics of the accidents?

(5) Through what policy and technical interventions can the risk of stadium accidents be most effectively reduced in regions with different economic conditions?

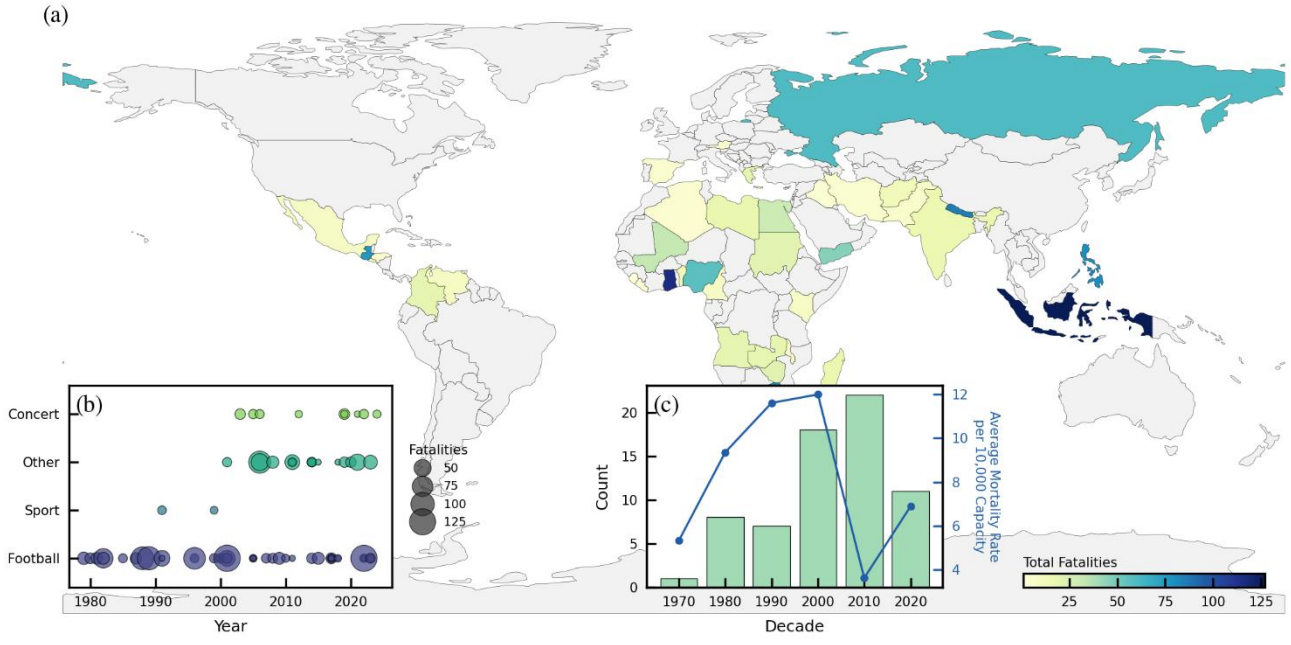


Fig. 1. Global analysis of stadium crowd-related casualties (CCA) between 1980 and 2024. (a) Geographical distribution of total fatalities; darker shades indicate higher cumulative mortality per country. (b) Temporal distribution of incidents categorized by event type (Football, Sport, Concert, and Other), with bubble sizes representing the number of fatalities per event. (c) Decadal trends showing the correlation between the frequency of incident occurrences (Count) and the average mortality rate normalized per 10,000 stadium capacity.

Materials and Methods

Terminology

Sports facility: Structures generally capable of accommodating tens of thousands of people. Typically, these are open-air (stadium) or enclosed (sports arena) facilities suitable for hosting sporting events. In addition to sports, they may serve as venues for other large-scale gatherings, such as concerts, political, or religious events (multifunctional facilities).

Crowd Crush Accident (CCA): Incidents arising from the movement of dense crowds [28,32,35,47–51], caused by compressive forces within the crowd [52–57] and critical density, excluding events related to fires. While earlier literature referred to these as "stampedes" [31], however, nowadays they are primarily defined by the terms trampling, crowd crush, surge/rush, crowd quakes, and collapse [51,58–60]. These may occur in quasi-static, dense crowds or in connection with the dynamic movement of the crowd, resulting in fatal asphyxiation [17–21,61,62].

Study Design and Research Workflow

A retrospective study was conducted to examine CCAs occurring in sports facilities using the "Tensor-Based CCA Database, TBDCA" [63] compiled by the author. This comprehensive database contains event data regarding CCA incidents derived from weighted-reliability press sources. The applied methodology provides an opportunity to analyze the security-technical and event-management impacts of mass disasters. Within the framework of the present study, the database records pertaining to events in sports facilities have been expanded. To facilitate a more in-depth investigation of the events and to identify the triggering causes of accidents occurring in sports facilities, numerous categorical variables were defined.

Data sources

The data are derived from the TBDCA [63] database, which contains information regarding fatal CCAs occurring between 1979 and 2024. Established in 2024, the database focuses specifically on accidents caused by the movement of dense crowds, excluding incidents related to fire and structural failures. The foundation of the database comprises press reports, eyewitness testimonies, video footage, as well as police, legal, and medical expert data. Compared to other compiled or published databases [64–71], it is characterized by continuous updates, relies on multiple sources, has no lower limit on the number of fatalities, and records the aftermath of the incidents as well. Each source was weighted based on reliability values.

The data collected and analyzed in the present study originate from CCA incidents occurring at events in sports facilities (location-specific keywords, including stadium, arena, and indoor/outdoor sports complex). The inclusion criterion was at least one fatality per incident. The expanded dataset, focusing on specific venues, included the following information: date, region, country, city, nature of the event, spatial characteristics, year of construction of the facility, design capacity, number of participants, cause of the accident, number of fatalities and injuries, and a description of the event (1. Table).

As an indicator of economic development, GDP per capita adjusted for purchasing power parity (GDP per capita, PPP, constant 2021 international $) was applied. The data source for the period between 1990 and 2024 is the World Bank World Development Indicators [72], while for preceding years and missing data, the Maddison Project Database (2020) [73] was utilized. Values from the latter database were integrated into the dataset using conversions adjusted to the base year.

Categorical Variables

(1) Subregions Category

The designation of subregions was determined based on the classification of the United Nations Statistics Division (UNSD) [74].

(2) Event Type Category

The classification of the nature of the events was conducted according to the following categories:

Football: Football sporting event.

Sport: Other, non-football sporting events.

Concert: Periodically organized musical events of a few hours' duration, generally centered around a single performer.

Other: Events that cannot be classified into the above categories (e.g., state, political, or religious events).

(3) Architectural Style Category

A four-variable category determined by the year of construction, as follows: traditional (built before 1920), modernist (1920–1970), postmodern (1970–2000), and contemporary (from 2000 to the present). The term commonly used as "retro" summarized facilities built between 1950 and 1980.

(4) Cause of Incident Category

The categorization of the examined events was based on the primary physical mechanism of crowd dynamics and the directions of movement, through the analysis of triggers documented in reports and environmental conditions (crowd movements forced by the physical environment):

Inflow: Incidents that developed during entry into the facility, at the entry points (gates, ticket checkpoints). The dynamic process is characterized by crowd movement directed toward the interior of the stadium accompanied by congestion, often triggered by time pressure related to the start of the event, attempts at unauthorized entry without tickets, or a sudden rush occurring upon gate opening.

Outflow: Events occurring during the egress process, which took place before the end of the event or immediately following it, during movement toward the exits. The basis of the mechanism is the congestion of the crowd moving outward from the interior space within exit corridors or stairwells representing bottlenecks.

Blockage: This category includes cases where, regardless of the direction of movement, an unexpected physical obstacle—typically a locked gate, barred exit, or delayed gate opening—halted the flow of the crowd. From a physical perspective, the highest static pressure develops during these incidents, as the continuously arriving influx presses those in front against the closed obstacle.

Escape: Uncontrolled crowd movement triggered by an external threat (e.g., police use of tear gas, bomb threats, armed conflict, or natural events). The process is characterized by high-velocity flow due to the compulsion to flee, which often leads to entrapment in narrow exits or being crushed against walls.

Density-driven: This group includes incidents due to the significant exceeding of seating capacity, where the determining factor was not the direction of movement but the extreme number of persons present in the area (overcrowding). The dynamics are characterized by quasi-static crushing, where the density of physical contact between participants reaches a level that inhibits free breathing and movement.

Infrastructure: Events where the geometric design or failure of the built environment (e.g., steep, slippery, or icy stairs, barrier collapse, darkness due to power failure) was the direct trigger of the accident. These conditions often initiate mass collapse (pile-up) or a domino effect through individual stumbles.

Conflict: Congestions resulting from violent clashes or fights between supporter groups, where part of the crowd is pressed against barriers or walls while attempting to move away from the conflict.

During all classifications, unknown values were placed in the "No data" category.

Definition of Indicators

The mortality rate projected against the participation rate is determined as the quotient of the number of deaths resulting from crowd crush accidents (CCA) and the measured or estimated number of participants. The indicator is calculated by dividing the number of fatalities by the total crowd size, with the result expressed in percentage form. Missing participant data were substituted with the design capacity of the facility.

Analysis

During the analytical process, first, a comprehensive descriptive statistical evaluation was prepared, which initially examined the entire dataset and subsequently detailed the results by category. This was followed by a comparative analysis between specific categorical variables and injury/mortality data.

The exploration of relationships between variables was conducted using Spearman's rank correlation analysis, which is suitable for handling non-linear relationships and ordinal data, taking into account the non-normal distribution of the data. Statistical significance levels were defined as $*p < 0.05$, $**p < 0.01$, and $***p < 0.001$. To identify multivariate patterns, hierarchical cluster analysis was performed based on a Spearman-based distance matrix, and the results were displayed on a correlation heatmap supplemented with a dendrogram. The processing and visualization of data were carried out in a Python environment (using Pandas, SciPy, and Seaborn libraries).

Results

Based on the data, a total of 67 fatal CCA mass disasters can be identified in sports facilities between 1979 and 2024 across 42 different countries. These incidents are summarized in 1. Table.

During the examined events, the total number of fatalities was 1,470, while the number of injured persons amounted to 4,672. The highest numbers of fatalities were claimed by crowd movements during football matches in Ghana (Accra, 2001, 127 deaths) and Indonesia (Malang, 2022, 125 deaths). In both cases, the tragedies were triggered by crowd alarm and police intervention. The event with the highest number of recorded injuries (647 persons) was the 1989 accident at the Hillsborough Stadium in England [20,75,76], where, due to police error, the crowd pressing into overcrowded sectors crushed supporters against the fences, resulting in 97 fatalities and 647 injuries.

Among the analyzed events in sports facilities, the largest crowd size was observed at a 2006 political event in Yemen, where the number of participants reached 150,000. Here, at the end of the election rally, alarm broke out within the massive crowd attempting to exit the stadium simultaneously, causing the deaths of 51 people and injuring 238 at the exits. The CCA accident occurring in the smallest crowd (200 people) took place in Alexandria, Egypt, on January 11, 1999, when 11 people lost their lives during a congestion outside the stadium (Blockage). Based on the data, CCA incidents in sports facilities occur across a wide range of crowd sizes. The heterogeneity observed in the results (number of fatalities and injuries, participant numbers, site characteristics, triggering factors) necessitates a more detailed investigation.

According to 2. Table, the distribution of incidents and victims shows significant geographical and functional concentration. Africa registered the highest number of events (42 cases) and fatalities (639 people), accounting for nearly 47% of total deaths. Globally, football matches are the most vulnerable (42 cases, 883 victims), and the highest number of fatal CCA accidents occurred during African football matches (407 deaths, 29.9%). At the same time, the data highlight that non-sporting events (political and religious rallies) in Asia and Africa are proportionately much more devastating: the number of victims per incident is significantly higher here than in the case of concerts or other sports.

1. Table Global distribution of stadium-related fatalities and incidents (1979–2024).

Year	Country	City	Fatalities	Year (2)	Country (2)	City (2)	Fatalities (2)
1979	Nigeria	Lagos	24	2009	Côte d'Ivoire	Abidjan	22
1980	India	Kalkutta	16	2010	Kenya	Nairobi	7
1981	Greece	Piraeus	21	2011	Nigeria	Port Harcourt	11
1982	Russian Federation	Moszkva	66	2011	Mali	Bamakó	36
1982	Colombia	Cali	22	2011	Congo	Brazzaville	7
1985	Mexico	Mexikóváros	10	2011	Indonesia	Jakarta	2
1987	Libya	Tripoli	20	2012	Spain	Madrid	5
1988	Nepal	Katmandu	93	2014	Nigeria	Abuja	12
1989	UK	Sheffield	97	2014	Democratic Republic of the Congo	Kinshasa	15
1991	South Africa	Orkney	42	2014	Pakistan	Multan	7
1991	Kenya	Nairobi	1	2014	Zimbabwe	Kwekwe	11
1991	USA	New York	9	2015	Egypt	Kairó	22
1996	Zambia	Lusaka	9	2015	Cameroon	Bepanda	1
1996	Guatemala	Guatemala City	84	2017	Angola	Uíge	17
1999	Egypt	Alexandria	11	2017	Honduras	Tegucigalpa	5
1999	Austria	Innsbruck	6	2017	Malawi	Lilongwe	8
2000	Liberia	Monrovia	3	2017	South Africa	Johannesburg	2
2000	Zimbabwe	Harare	13	2018	Sierra Leone	Freetown	1
2001	South Africa	Johannesburg	43	2018	Madagascar	Antananarivo	1
2001	Congo	Lubumbashi	14	2018	Angola	Luanda	5
2001	Ghana	Accra	127	2019	Nigeria	Port Harcourt	15
2001	Venezuela	Caracas	11	2019	Madagascar	Antananarivó	16
2003	Benin	Cotonou	16	2019	Algeria	Algír	5
2005	Madagascar	Antananarivó	2	2020	Afghanistan	Jalalabad	15
2005	Iran	Teherán	6	2021	India	West Bengal, Kalimpong	2
2005	Kenya	Nairobi	1	2021	United Republic of Tanzania	Dar es Salaam	45
2005	Republic of Korea	Sangju	11	2022	Cameroon	Yaounde	8
2006	Philippines	Manila	88	2022	Indonesia	Malang	2
2006	Yemen	Khaled Al-Mahdi	51	2022	Indonesia	Malamg	125
2006	Indonesia	Pekalongan	10	2022	Democratic Republic of the Congo	Kinshasa	11
2007	Zambia	Chililabombwe	12	2023	Iraq	Basra	4
2008	Sudan	Omdurman	23	2023	El Salvador	San Salvador	12
2008	Congo	Kinshasa	13	2023	Congo	Brazzaville	31
				2024	Congo	Kinshasa	7
						Total fatalities	1470

2. Table Number of incidents and associated fatalities (in parentheses, with percentage of regional total) by region and event type.

Continent	Football	Other Sport	Concert	Other (Pol., Rel.)	Total	Global Victim %
Africa	24 (407; 63,7%)	0 (0; 0%)	5 (56; 8,8%)	13 (176; 27,5%)	42 (639)	46,9%
Asia	7 (154; 44,8%)	0 (0; 0%)	3 (19; 5,5%)	3 (171; 49,7%)	13 (344)	25,3%
Europe	5 (189; 91,7%)	1 (6; 2,9%)	2 (11; 5,4%)	0 (0; 0%)	8 (206)	15,1%
North and Central America	5 (111; 79,3%)	1 (9; 6,4%)	2 (20; 14,3%)	0 (0; 0%)	8 (140)	10,3%
South America	1 (22; 66,7%)	0 (0; 0%)	0 (0; 0%)	1 (11; 33,3%)	2 (33)	2,4%
TOTAL	42 (883; 64,8%)	2 (15; 1,1%)	12 (106; 7,8%)	17 (358; 26,3%)	73 (1362)*	100%

* Note: The aggregate number of victims (1,362) is higher than the actual sum of unique cases (1,331) due to overlaps between categories (e.g., simultaneous sports and concert events).

Based on Fig. 2(a), the incidents claiming the highest number of victims are concentrated in West Africa and Southeast Asia. (b) Regarding the average construction year of buildings involved in stadium accidents, the oldest buildings were located in the Northern European and South Asian subregions, while in Asia and certain parts of Africa, more modern facilities built around the turn of the millennium dominate. (c) The examination of capacity shows that Eastern Europe and Africa had the accident sites with the highest average stadium capacities. (d) The analysis of the economic background highlights the correlation between GDP per capita and the stadium security environment, indicating that most fatal accidents are concentrated in regions with lower purchasing power parity.

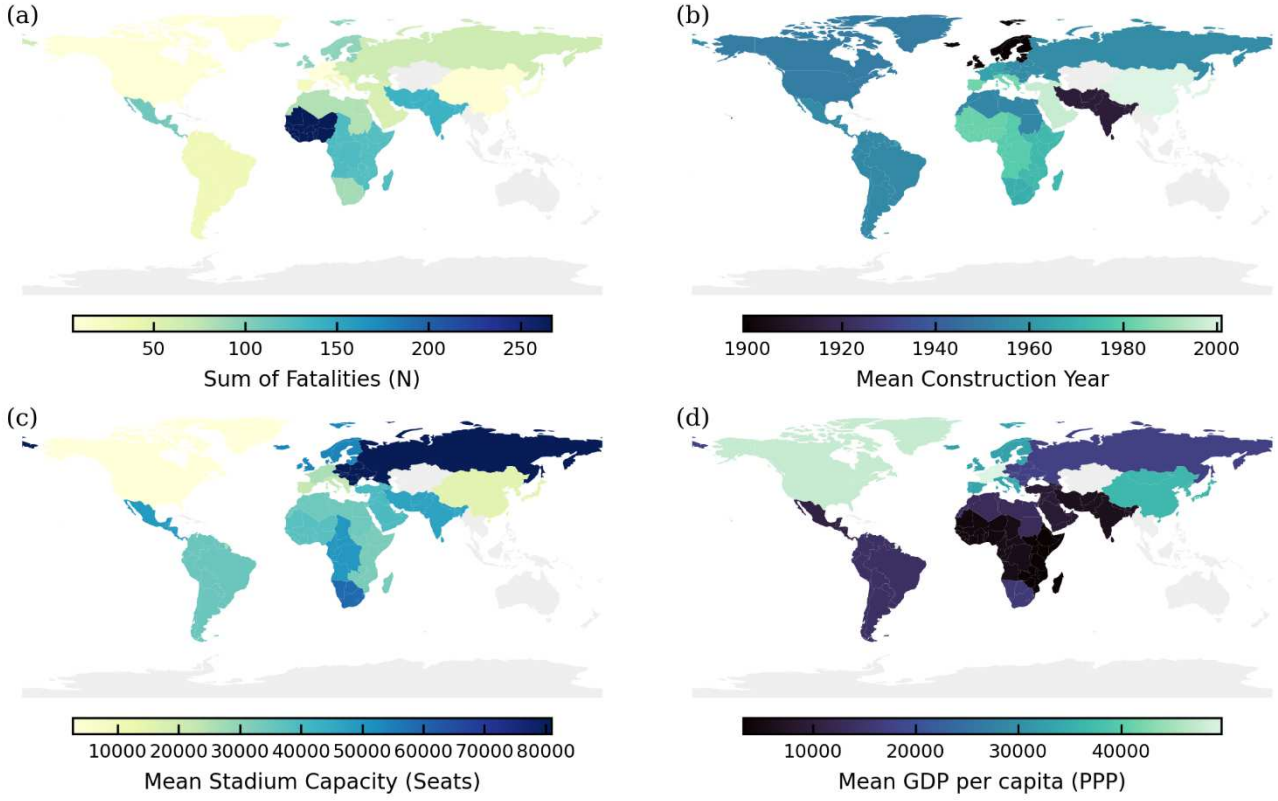


Fig. 2. Global geographical distribution of stadium crowd disasters. (a) Total fatalities attributed to progressive crowd collapse and traumatic asphyxia by UN sub-region; (b) Mean construction year of stadiums involved in fatal incidents by region.

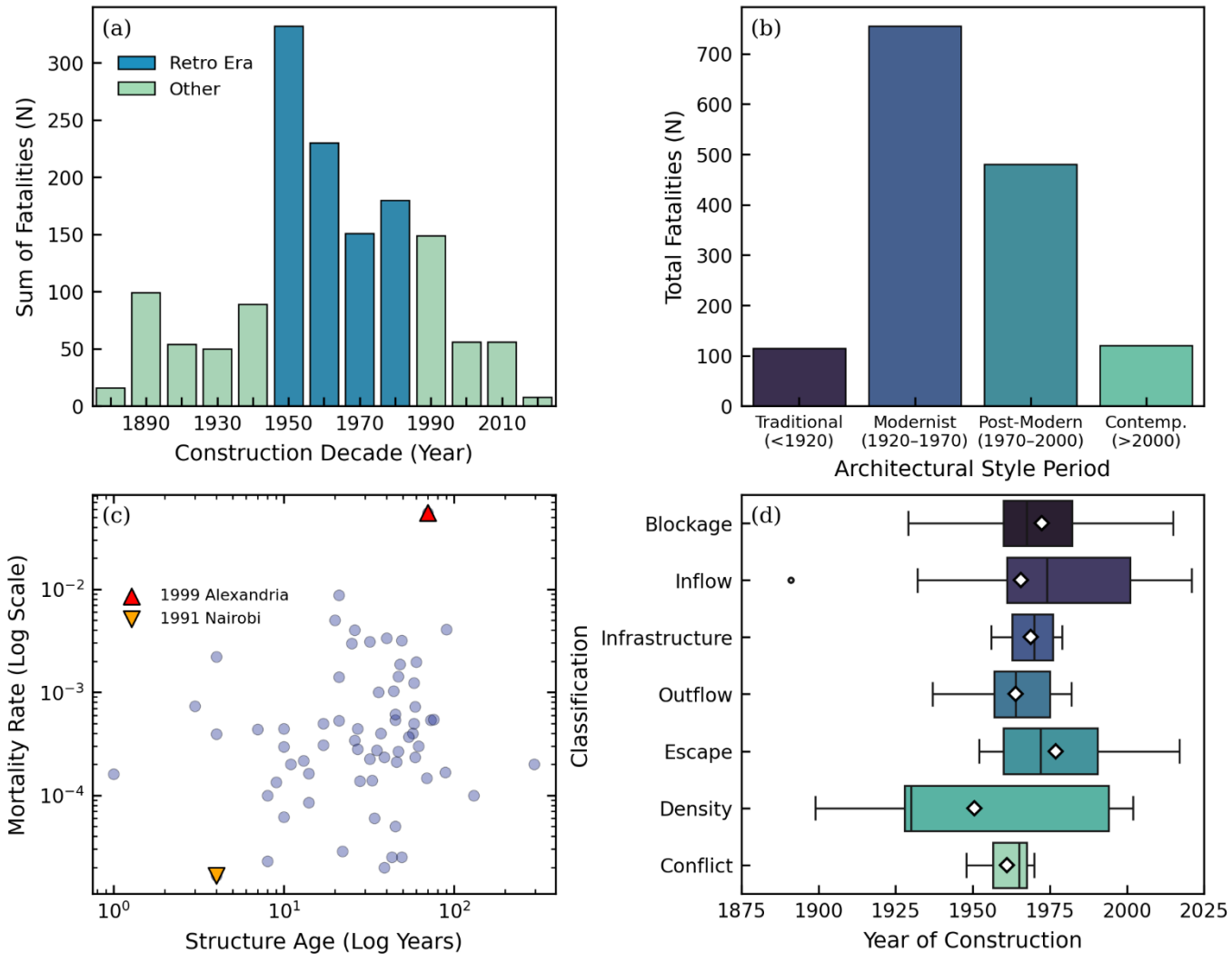


Fig. 3. Statistical analysis of stadium incidents in relation to architectural periods and structures. (a) Sum of fatalities by construction decade; (b) Total fatalities categorized by architectural style periods; (c) Correlation between mortality rate and structure age at the time of the incident (logarithmic scale); (d) Distribution of incident classifications across construction years.

Based on Fig. 3(a), the number of fatalities is highest in stadiums built during the period between 1950 and 1990 (the so-called "Retro Era"), within which facilities inaugurated in the 1950s stand out with more than 300 victims. (b) The examination of architectural style eras shows that most deaths (more than 700 people) are linked to modernist (1920–1970) style stadiums, while incidents occurring in traditional (<1920) and contemporary (>2000) buildings claimed the fewest victims. (c) The correlation between the age of stadiums and the mortality rate does not show a linear trend; the data exhibit significant variance, where the 1999 Alexandria tragedy features an outstandingly high mortality rate, while the 1991 Nairobi event has a specifically low mortality rate relative to the age of the building. (d) Based on the boxplot examining the relationship between accident classification and the year of construction, the median for most event types (blockage, inflow, infrastructure, outflow) falls between the construction years of 1960 and 1975; however, density-driven accidents occur across the widest range (approx. 1900–2000) regarding the time of construction.

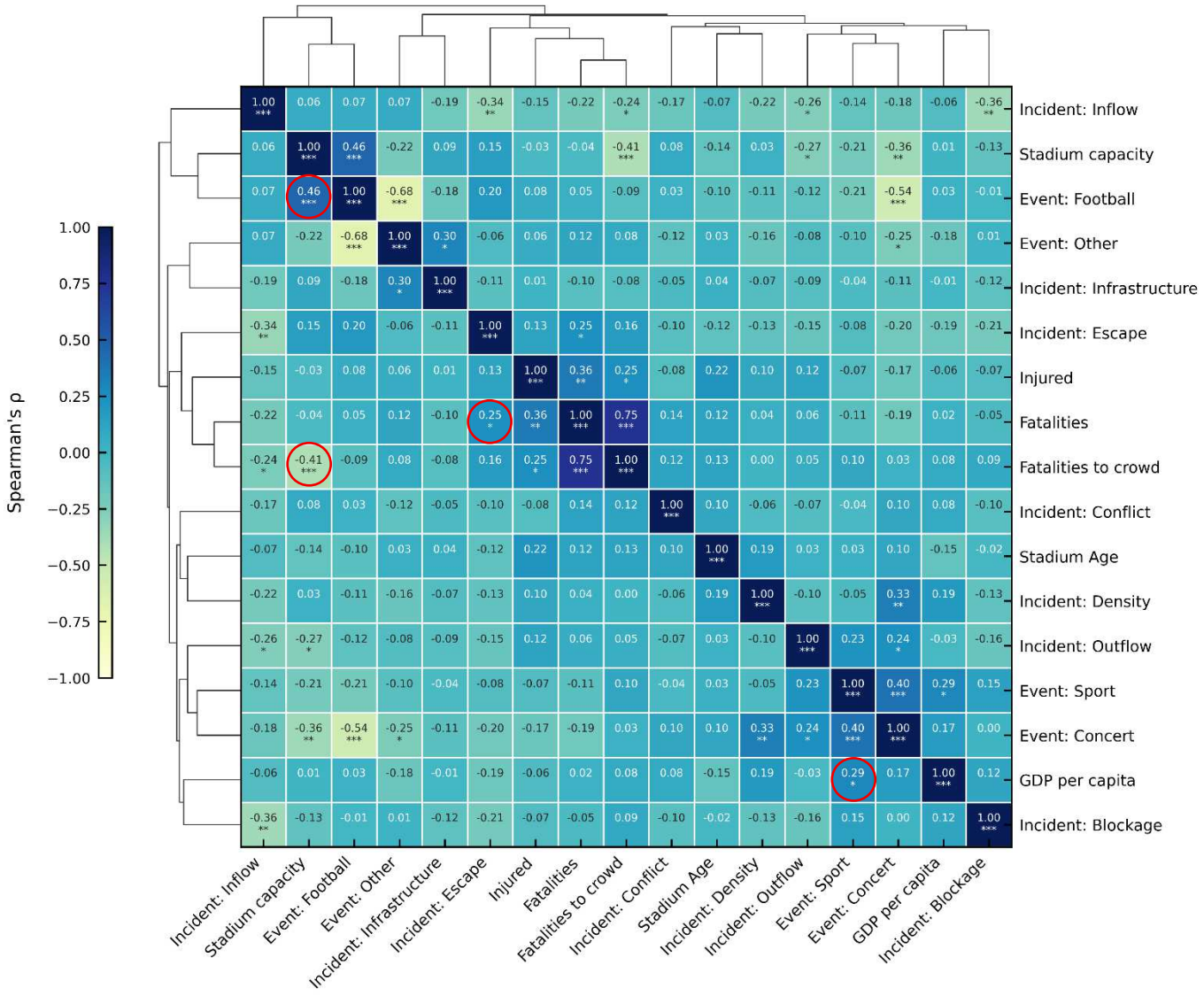


Fig. 4. Hierarchical clustered Spearman rank correlation matrix of stadium incident variables (*p < 0.05, **p < 0.01, ***p < 0.001). The dendrogram represents variable grouping based on Spearman's ρ dissimilarity, highlighting the co-occurrence patterns between architectural parameters, economic indicators, and disaster outcomes.

Based on Fig. 4, Spearman's rank correlation and hierarchical clustering revealed several significant associations. An extremely strong and statistically highly significant positive correlation is observed between the number of fatalities and crowd-projected mortality (Fatalities to crowd) ($\rho = 0.75$, $p < 0.001$). Stadium capacity shows a significant positive correlation with football matches ($\rho = 0.46$, $p < 0.001$), while simultaneously showing a strong negative correlation with the ratio of deceased relative to crowd size ($\rho = -0.41$, $p < 0.001$). Although the relationship between GDP per capita and sporting events is weaker, it is statistically supported ($\rho = 0.29$, $p < 0.05$), whereas no significant correlation can be detected with stadium age. A moderate but significant positive correlation exists between escape difficulties (Incident: Escape) and the number of fatalities ($\rho = 0.25$, $p < 0.05$), confirming the critical role of blocked exits in the outcome of accidents.

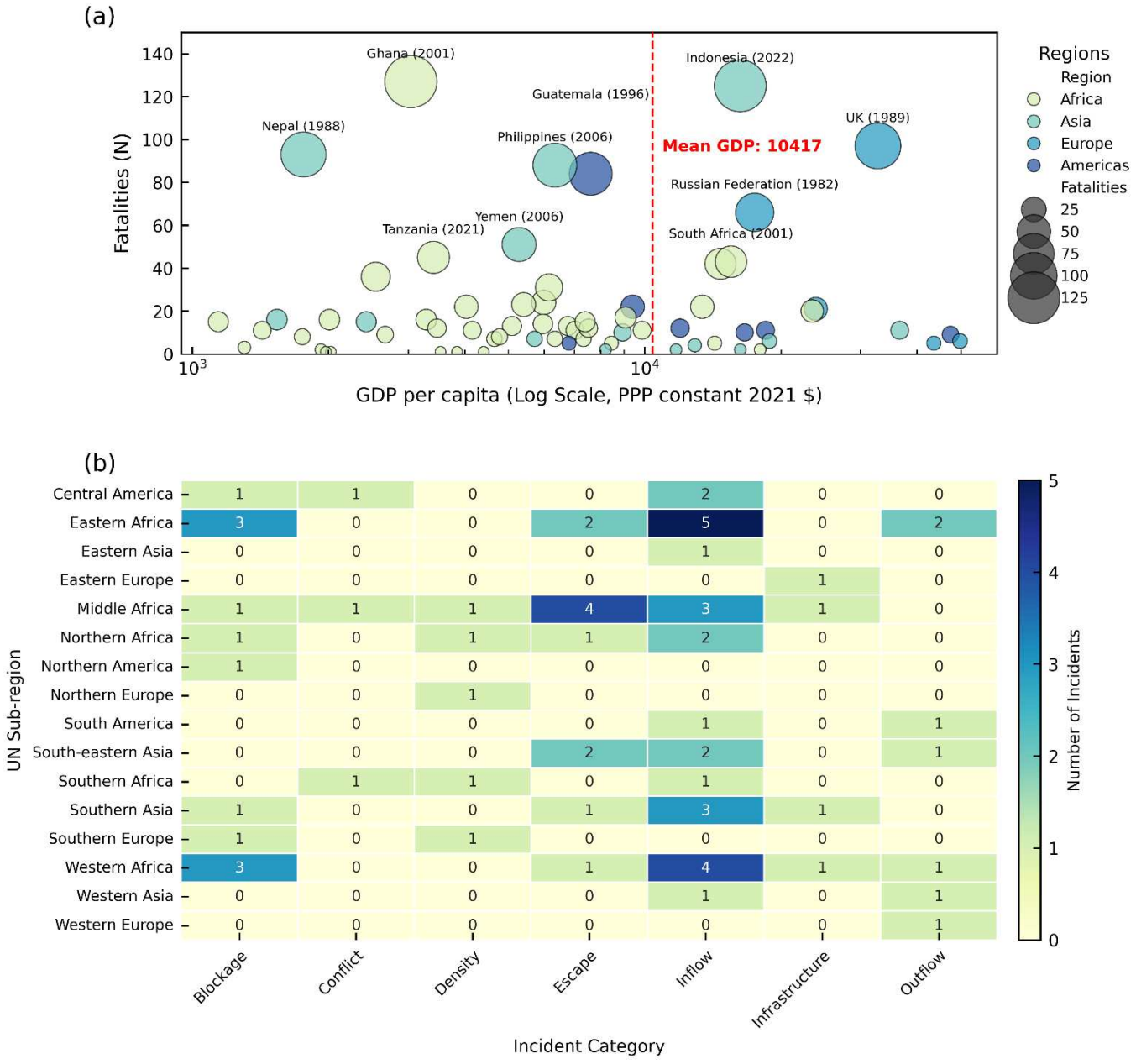


Fig. 5. Socio-economic and geographic distribution of stadium CCA-disasters. (a) Scatter plot of fatalities versus GDP per capita (logarithmic scale). (b) Frequency matrix of incident categories across various UN sub-regions.

Based on Fig. 5(a), most incidents involving a high number of victims are concentrated in regions below the average GDP ($10,417) (e.g., Ghana, Nepal, Philippines). At the same time, it is evident that outlier cases also occur in higher-income countries, as demonstrated by the examples of the United Kingdom (1989) or Indonesia (2022). Fig. 5(b) clearly shows that accidents resulting from inflow (Inflow) are the most frequent, particularly in East, West, and Central Africa. East Africa and West Africa stand out in the number of incidents caused by blockage (Blockage), while escape difficulties (Escape) emerge as a critical factor primarily in Central Africa and Southeast Asia. Based on the data, tragedies caused by infrastructural failures and conflicts (Conflict) show a relatively low number of cases globally and appear sporadically across the various subregions.

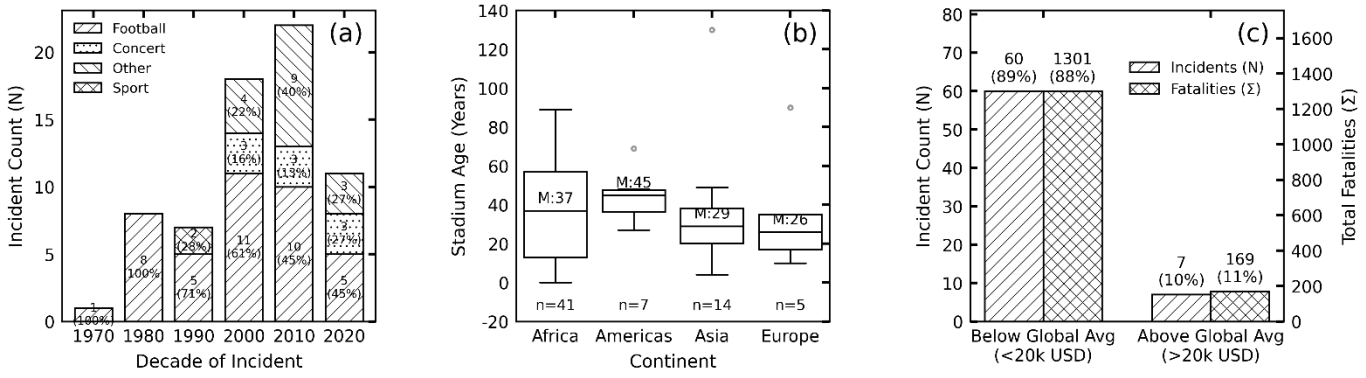


Fig. 6. Global distribution and temporal trends of stadium-related CCA incidents (1979–2025): (a) Number of incidents by decade and event type; (b) Distribution of stadium age at the time of incident by continent; (c) Comparison of total incidents and fatalities based on GDP per capita (global average threshold at $20,000).

The data confirm that the lack of inflow (Inflow) control is the most universal risk factor, which is present regardless of region, but is realized in its most severe form in the African and Asian subregions with lower GDP. The figure highlights that economic development does not provide complete protection against mass disasters, but the nature of the accidents (e.g., blockage vs. inflow) shows significant regional variations.

Based on Fig. 6(a), the number of cases shows a rising trend starting from the 1970s, reaching its highest values in the 2010s (n=22). In the distribution by event type, the dominance of football can be observed until 2000. Starting from the 2000s, incidents occurring during other events and concerts also appear in the dataset, accounting for more than 50% of the total number of cases in the last two decades. Based on Fig. 6(b), the median age of stadiums recorded at the time of fatal CCA incidents was highest in America (45 years) and lowest in Europe (26 years). Fig. 6(c) clearly shows that the majority of accident events (n=60, 89%) and fatalities (n=1,301, 88%) occurred in countries below the average GDP ($20,000). The mean GDP of countries below the average was $7,603 (SD: 5,464), while for those above the average, it was $39,019 (SD: 8,952)

Discussion

Based on the results of the study, fatal crowd crush accidents (CCA) occurring in stadiums are not stochastic events but follow systemic spatial and socio-economic patterns [4,30,40]. The analysis of 67 incidents between 1979 and 2025 highlights a shift in the center of gravity toward developing regions, which supports the theory of "security transition": while stricter regulatory environments in high-income countries have curtailed fatal events, infrastructural development in lower-income countries has not kept pace with the demand for mass events [77–80].

The results confirm that CCA accidents are directly correlated with the macroeconomic status of the region and the legacy of architectural eras. This dual determinism (technological deficit and structural obsolescence) creates "risk nodes" where crowd management errors inevitably lead to disaster. With this, the study offers a new component for an interdisciplinary framework [81] for the assessment of stadium security, which integrates physical parameters with significant socio-economic predictors (e.g., income and culture).

Limitations

The present study has several limitations. Firstly, the database does not include every incident related to sports facilities in which a crowd crush accident (CCA) occurred. The data depend on the reporting systems and data collection methods of individual countries, and only publicly accessible data were utilized during

the investigation. Secondly, the nature of CCA incidents occurring in stadiums presents methodological challenges. Accidents involving large crowds are often underreported, misclassified, or concealed for various reasons—including political or economic factors. Thirdly, the results of the study emphasize the importance of the role of law enforcement agencies (e.g., police conducting raids) and security personnel; however, no data are available regarding whether trained security personnel were present at the sites at the time of the accidents, nor on the nature of the specialized training received by the police officers. This results in an underestimation of the actual patterns.

Conclusion

The study examined fatal mass disasters of crowd dynamics origin occurring in stadiums between 1979 and 2025, excluding fire as a primary trigger. The results can be summarized as follows:

(1) The research highlights that the foremost universal risk factor for stadium incidents is the lack of inflow control, which defines the security situation regardless of the region. Based on the analysis of datasets, the most severe tragedies can be directly traced back to police failures, while a significant historical shift is observable in terms of event types. While the dominance of football was characteristic until 2000, in the last two decades, the proportion of incidents occurring during concerts and other events (multifunctional stadium use) has already exceeded 50% of all cases, justifying the necessity of extending security protocols.

(2) Based on global data, fatal stadium accidents occurred in the highest proportion during African football matches, where the number of victims reached 407 (29.9%). At the same time, the research points out that non-sporting events in Asia and Africa—especially political and religious rallies—are proportionately much more devastating, as the number of victims per incident is significantly higher here than in the case of concerts or other sports. From a geographical perspective, incidents claiming the most victims were markedly concentrated in West Africa and Southeast Asia.

(3) The average stadium capacity of accident sites was highest in Eastern Europe and Africa, while stadium size shows a significant positive correlation with football matches ($\rho = 0.46$, $p < 0.001$). Simultaneously, larger capacity stands in strong negative correlation with inflow incidents ($\rho = -0.41$, $p < 0.001$), indicating that tragedies occurring during ingress are rarer in larger facilities. Regarding construction eras, the number of fatalities was highest in stadiums built between 1950 and 1990 ("Retro Era"), and more broadly in modernist style (1920–1970) facilities, with the latter exceeding 700 victims. Although the median for most incident types is concentrated in the construction years between 1960 and 1975, accidents arising from crowd density occurred across the widest range (1900–2000) in terms of construction period. Finally, the significant positive correlation between escape difficulties and the number of fatalities ($\rho = 0.25$, $p < 0.05$) confirms the critical role of blocked exits in the severe outcome of accidents.

(4) The overwhelming majority of stadium accidents (n=60; 89%) and the decisive portion of fatalities (n=1301; 88%) were concentrated in countries below the global average GDP ($20,000). Although the relationship between GDP per capita and sporting events is more moderate ($\rho = 0.29$, $p < 0.05$), incidents resulting from inflow, as universal risk factors, were present in every region, but in their most severe form in the lower-income African and Asian subregions. East and West Africa stand out in the number of events caused by the lack of ingress control and blockage, while escape difficulties emerged as a critical factor in the outcome of tragedies primarily in Central Africa and Southeast Asia.

(5) The results of the research highlight that stadium security strategies must be adapted to local economic and infrastructural realities. In regions with lower GDP, copying Western security protocols is insufficient; the modernization of physical ingress systems and the removal of obstacles from escape routes must be handled as primary priorities. Global football organizations and local authorities must focus on real-time crowd density control and stricter regulation of inflow instead of increasing capacity to prevent tragedies.

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