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REVIEW

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# Global research trends on maxillofacial injuries in children from 2004 to 2024: a visual analysis based on CiteSpace

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## Abstract

Maxillofacial injuries affect 1% to 14% of children under 16 years and 0.87% to 1% of those under 5 years old, significantly impacting quality of life and posing challenges in prevention and treatment. Using CiteSpace 6.4.R1, we analyzed 1018 English-language publications from the Web of Science Core Collection (2004–2024) to identify research trends and collaboration patterns. The literature contributed by 4270 authors from 2651 institutions in 330 countries/regions, clusters into three domains: maxillofacial fractures, etiology-specific injuries, and socioeconomic/epidemiological factors. Highly cited articles included those by Grunwaldt L (2011), Andrew TW (2019), and Wymann NME (2008). Prominent highly cited authors were Haug Rh and Gassner R. The journals with the highest co-citation frequency were the Journal of Oral and Maxillofacial Surgery and Plastic and Reconstructive Surgery. Findings indicate accelerated growth yet fragmented global collaboration in pediatric maxillofacial injury research, dominated by the United States. The research priorities include epidemiology, clinical management, and socioeconomic determinants; emerging frontiers focus on dynamic risk quantification, minimally invasive fixation, and policy impact assessment. Consequently, future work requires enhanced global synergy and personalized prevention strategies.

## Keywords

Maxillofacial injuries; Facial injuries; Children; Pediatrics; Epidemiologic factors

## 1. Introduction

Injuries are common in all kinds of people around the world. Among these injuries, maxillofacial injuries are a significant cause of morbidity in the pediatric population. Maxillofacial trauma is one of the major global public health problems and can cause damage to bone, dentition, and facial soft tissues [1, 2].

The face is the foundation of all human interactions, and structural damage to the face has a lasting and devastating impact on the life quality of patients. Maxillofacial injuries in individuals under 16 years of age ranged from 1% to 14%, while in children under 5 years, the range was 0.87% to 1% compared to the adult population [3]. Children have a relatively high head-to-body mass ratio, which makes them more vulnerable to craniofacial injuries [4]. Therefore, it is a great challenge to the prevention, treatment, and care of maxillofacial injuries in pediatric patients [5].

Previous studies indicated that boys experienced more trauma than girls, with preschool-age children being the most frequently affected. The leading causes of injury were road traffic accidents and falls, and soft tissue injuries were identified as the most common type of injury [6, 7].

However, maxillofacial injury characteristics and epidemiology vary significantly across regions and countries due to socioeconomic, political, cultural, and environmental factors [8, 9]. Understanding the epidemiological factors and studying the progress of maxillofacial injuries are very important for making appropriate clinical treatment and prevention plans.

Bibliometrics effectively describes trends in research fields, particularly in medical research [10]. CiteSpace, a specialized software designed for visualizing and analyzing emerging trends in scientific literature, has been widely used to summarize and predict research directions [11, 12]. It enables researchers to identify research progress and detect evolving hotspots within a domain [13]. In recent years, there has been a lot of research related to maxillofacial injuries in children, but this research is relatively scattered, and lacks bibliometric analysis. To better understand the developments in the field of maxillofacial injury research in children, we aim to evaluate countries, regions, and institutions serving as key hubs of collaborating networks in the research landscape of maxillofacial injuries in children. In addition, determine the research priorities in the field of maxillofacial injuries in children.

## 2. Materials and methods


  

## 2.1 Search strategies

Studies addressing maxillofacial injuries in children were identified from the Web of Science Core Collection (WoSCC). A comprehensive search strategy was implemented to retrieve complete Web of Science (WoS) records pertinent to this investigation, and the retrieval strategy was as follows: TS (Topic) = (((maxill* OR facial OR craniofacial OR oral) AND (traum* OR injur*)) AND (child* OR p$ediatr*)). The search encompassed publications from 01 January 2004 to 31 December 2024, with language restricted to English.

Inclusion was restricted to: (1) publications with a central focus on maxillofacial injuries in children; (2) article types including clinical trials, case reports, animal studies, literature-based research, and reviews; (3) complete bibliographic information available, including titles, authors, keywords, sources, *etc.*; and (4) the publication's language was English.

Exclusion Criteria: (1) non-research materials including meeting abstracts, letters, book reviews, and corrections; (2) publications with incomplete metadata or duplicate entries; and (3) publications unrelated to the "children's maxillofacial injuries" focus.

## 2.2 Data collection

Screening of titles, abstracts, and full texts was conducted independently by two reviewers. Conflicts were adjudicated by a third subject-matter expert. A total of 4837 articles were retrieved, and "Full record with referenced references" was selected. After CiteSpace-assisted deduplication, 1018 documents qualified for analysis (Fig. 1). Complete records and cited references of the 1018 publications were retrieved in plain text format to facilitate visualization and analysis.

## 2.3 Data analysis

Data analysis and visualization were done in Microsoft Excel (version 16.0.19029.20136, Microsoft Corporation, Redmond, WA, USA) and CiteSpace (version 6.4.R1, Dr. Chaomei Chen, Drexel University, Philadelphia, PA, USA). Excel was used to analyze the research's annual publication trends. CiteSpace was used to generate bibliometric networks visualizing collaborative, co-occurrence, co-citation relationships, and the research trend. Analytical dimensions encompassed authors, countries/regions, institutions, journals, keywords, and citations. Co-occurrence mapping identified significant scientific

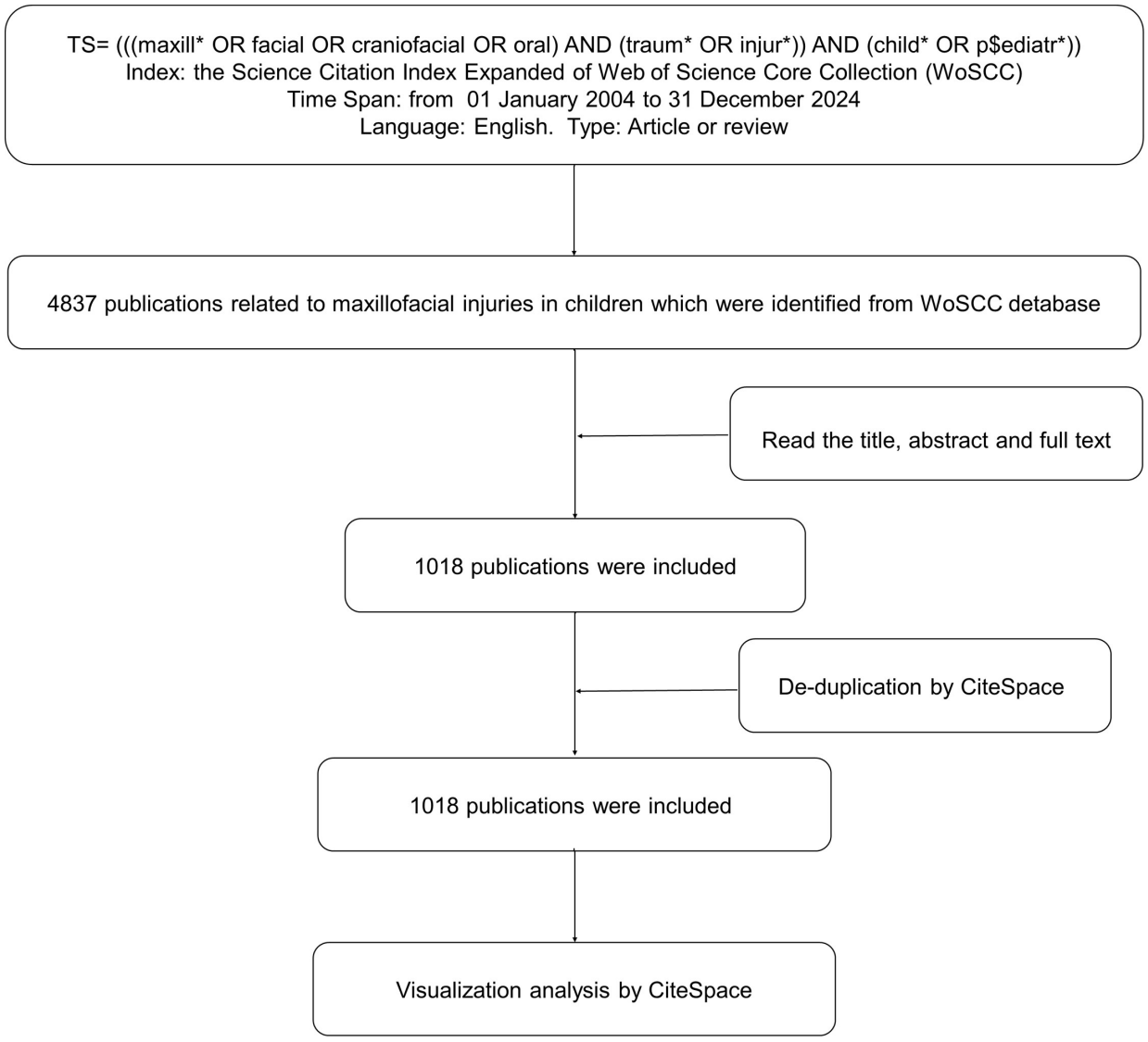


**FIGURE 1. Flow chart of the literature screening process.** TS, Topic.

terms within the literature corpus. Literature information was assessed by country/region and author affiliation, employing quantitative indices such as citation counts and journal impact factors.

## 3. Results

The 1018 articles were authored by 4270 individuals from 2651 research institutions across 330 countries/regions, and published in 305 journals.

### 3.1 Cooperation network analysis

#### 3.1.1 Annual publication analysis

The annual publication volume of articles is shown in (Fig. 2A). The number of published articles grew from 28 in 2004 to 99 in 2024, displaying a fluctuating trend. This growth can be divided into three main stages: the exploratory and fluctuating stage (2004–2011), the exponential growth stage (2012–2020), and the plateau and adjustment stage (2021–2024). The publication output reached the peak in 2024 (99 articles, 9.72%).

#### 3.1.2 Country/region contributions

The countries/regions shown in the visualization diagram published at least 26 articles (Fig. 2B). All 1018 articles involved 330 countries/regions, and the top 10 countries/regions contributed to 77.90% (793/1018) of the total article output. The United States contributed the most articles (420 articles, 41.26%), followed by India (62 articles, 6.09%), Brazil (59 articles, 5.80%), China (56 articles, 5.50%), England (42 articles, 4.13%), Turkey (40 articles, 3.93%), Italy (31 articles, 3.05%), Australia (29 articles, 2.85%), Germany (28 articles, 2.75%), and Canada (26 articles, 2.55%). England (0.29), Brazil (0.27), Scotland (0.25), Chile (0.20), and Canada (0.18) had higher betweenness centrality, and played an important bridging role in national cooperation networks in this field. Although the United States produced the most papers, its betweenness centrality was only 0.11. This indicates that the research was scattered and the level of cooperation was low.

#### 3.1.3 Institution contributions

All 1018 articles involved 2651 research institutions, and the institutions shown in the visualization diagram published at least 11 articles (Fig. 2C). Of these, the top 11 high-yielding institutions were the Pennsylvania Commonwealth System of Higher Education (PCSHE), Rutgers University System, Harvard University, University of Miami, Baylor College of Medicine, Johns Hopkins University, University System of Ohio, University of Pennsylvania, University of California System, University of Washington, and Wayne State University. Boston Children's Hospital was the most active organization with 8 articles, but the centralities of all the institutions were under 0.12.

#### 3.1.4 Author contributions

All 1018 articles involved 4270 authors. The co-operation network of authors is shown in (Fig. 2D). Different nodes represent various authors, with a circle size indicating the number of papers published by each author. The researchers who published the most papers were regarded as the leading experts in the field. Losee JE, Granick MS, Manson PN, Lopez J, Hoppe IC were the most prolific authors, all with at least 10 articles, followed by Lee ES (9 articles), Dorafshar AH (7 articles), Folbe AJ (7 articles), Halsey JN (7 articles), Stanbouly D (7 articles), and Svider PF (7 articles). Their betweenness centrality was all less than 0.01. Among them, Dorafshar AH, Lopez J, Manson PN, Granick MS, Halsey JN, Hoppe IC, and Lee ES had collaborated extremely closely.

### 3.2 Keyword analysis

#### 3.2.1 Co-occurrence analysis of keywords

Children had the highest frequency (349 times), followed by injury (247 times), management (198 times), trauma (176 times), facial fracture (168 times), and patterns (140 times), as shown in (Table 1, Fig. 3A). The research fields of maxillofacial trauma in children mainly thus focused on injury, management, facial fracture, trauma and pattern.

#### 3.2.2 Keyword clustering analysis

As shown in (Table 2, Fig. 3B), the keywords were clustered into 13 tags, which were derived from the log-likelihood ratio (LLR) algorithm. Cluster words reflected the research focus in the field of maxillofacial injuries in children, and were of great significance in predicting the development pattern and new research direction of the subject. From the LLR algorithm, it could be seen that clusters #0, #1, #2, #6, #7, and #9 were mainly related to facial trauma and fracture types; clusters #3, #4, #5, #10, and #11 were mainly injuries and complications associated with maxillofacial trauma; and clusters #8 and #12 were primarily about the socioeconomic impact, epidemiology, and outcomes of maxillofacial injuries.

#### 3.2.3 Keyword timeline analysis

As shown, topic cluster #0 had the most node numbers (Fig. 3C). The majority of topic clusters had been continuously studied, except for #8, #9, #11, and #12, which included topics such as location of injury, patient population, prognosis, and complications. Among them, the #0, #1, #2, #3, and #4 topic clusters had deep connections with others.

#### 3.2.4 Keyword citation bursts analysis

Keywords such as diagnosis, skeleton, and midfacial fractures, *etc.* had been in a state of high fever for a long time. Maxillofacial fractures had the strongest citation burst (6.70), followed by diagnosis (6.59), facial trauma (5.39), and pediatric trauma (5.02), as shown in (Fig. 3D).

### 3.3 Co-citation analysis

#### 3.3.1 Literature co-citations analysis

The articles of Grunwaldt L (2011) [14], Andrew TW (2019) [15], and Wymann NME (2008) [16] were the most cited among the 10 most frequently cited articles, and thus had a wide influence on maxillofacial trauma in children (Table 3, Ref. [14–23], Fig. 4A).

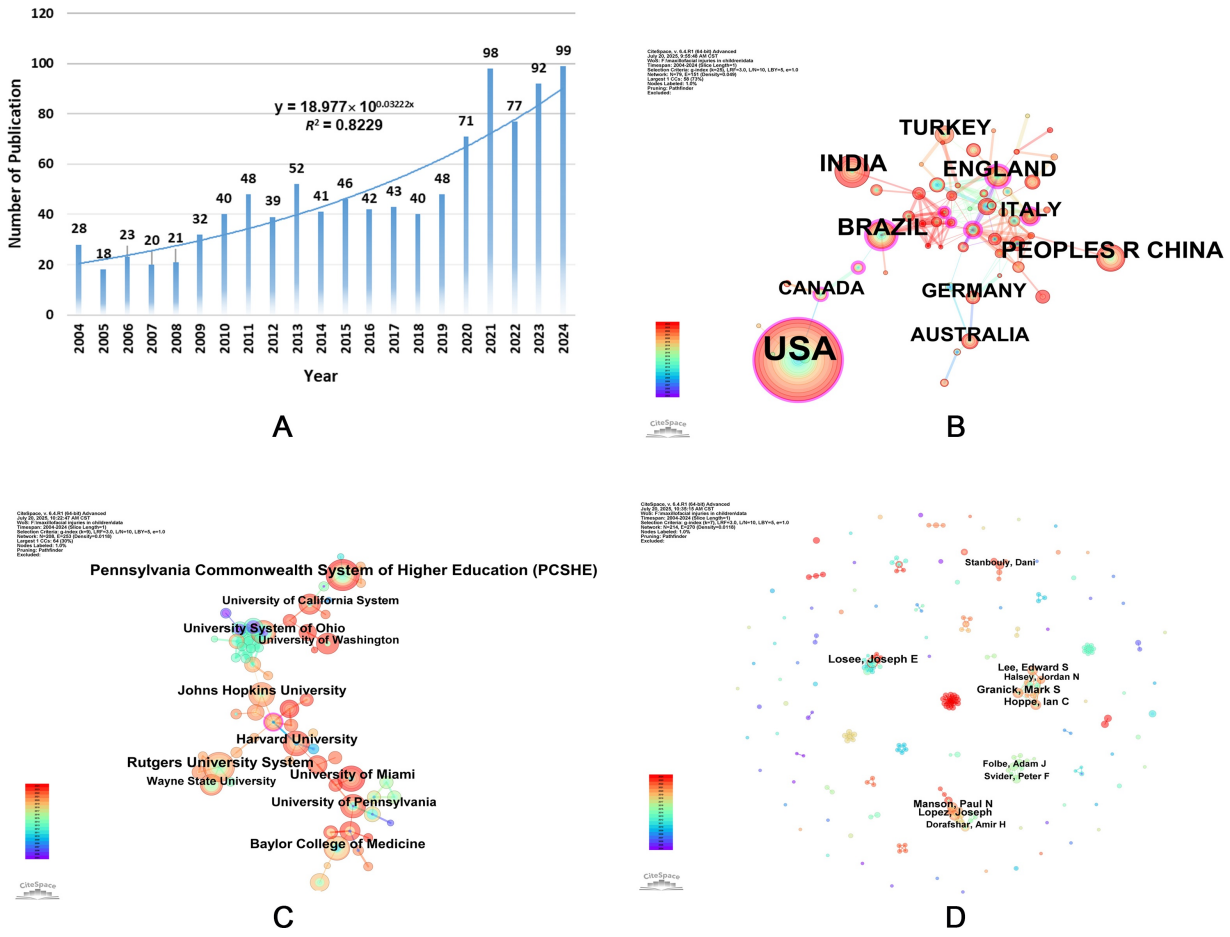


**FIGURE 2. The current state of literature publication.** (A) Annual publication volume of articles. (B) The co-operation network of countries/regions. (C) The co-operation network of institutions. (D) The co-operation network of authors. LRF, Link Retaining Factor; L/N, Links per Node; LBY, Look Back Years; CCs, Connected Components.

**TABLE 1. High-frequency keywords list.**

| Keyword | Frequency | Keyword | Frequency | Keyword | Frequency |
|---|---|---|---|---|---|
| Children | 349 | Diagnosis | 35 | Pediatric facial trauma | 16 |
| Injury | 247 | Facial fracture | 34 | Risk | 16 |
| Management | 198 | Prevalence | 33 | Classification | 15 |
| Trauma | 176 | Head | 32 | Etiology | 15 |
| Facial fractures | 168 | Pediatric trauma | 31 | Oral health | 15 |
| Patterns | 140 | Fixation | 29 | Repair | 15 |
| Bone fractures | 56 | Growth | 29 | Maxillofacial injury | 14 |
| Age | 54 | Dental trauma | 28 | Open reduction | 14 |
| Epidemiology | 52 | Head injury | 28 | Childhood | 13 |
| Fractures | 52 | Traumatic brain injury | 26 | Demographics | 13 |
| Facial trauma | 50 | Dog bite | 21 | Impact | 13 |
| Maxillofacial fractures | 49 | Skeleton | 20 | Orbital fractures | 13 |
| Pediatric facial fractures | 46 | Child abuse | 18 | Dental injury | 12 |
| Maxillofacial trauma | 41 | Condylar fractures | 18 | Dog bites | 12 |
| Adolescents | 39 | Complications | 17 | Internal fixation | 12 |
| Mandibular fractures | 38 | Computed tomography | 16 | Maxillofacial injuries | 12 |
| United states | 37 | Follow up | 16 | Pattern | 12 |

**TABLE 2. Keyword clustering based on the LLR algorithm.**

| Cluster ID | Silhouette Score | Average Year | Number of Nodes | LLR (Log-likelihood ratio) |
|---|---|---|---|---|
| #0 | 0.959 | 2011 | 26 | Pediatric facial trauma |
| #1 | 0.968 | 2013 | 24 | Facial trauma |
| #2 | 0.873 | 2009 | 23 | Pediatric facial fractures |
| #3 | 0.889 | 2011 | 20 | Traumatic brain injury |
| #4 | 0.905 | 2015 | 15 | Dental injury |
| #5 | 1.000 | 2013 | 14 | Diplopia |
| #6 | 0.918 | 2014 | 14 | Facial fracture |
| #7 | 0.982 | 2008 | 14 | Mandibular fractures |
| #8 | 0.917 | 2013 | 13 | Quality of life |
| #9 | 0.925 | 2007 | 10 | Facial injuries |
| #10 | 0.996 | 2010 | 8 | Traumatic dental injury |
| #11 | 0.901 | 2009 | 6 | Thrombosis |
| #12 | 0.983 | 2013 | 5 | Incidence |

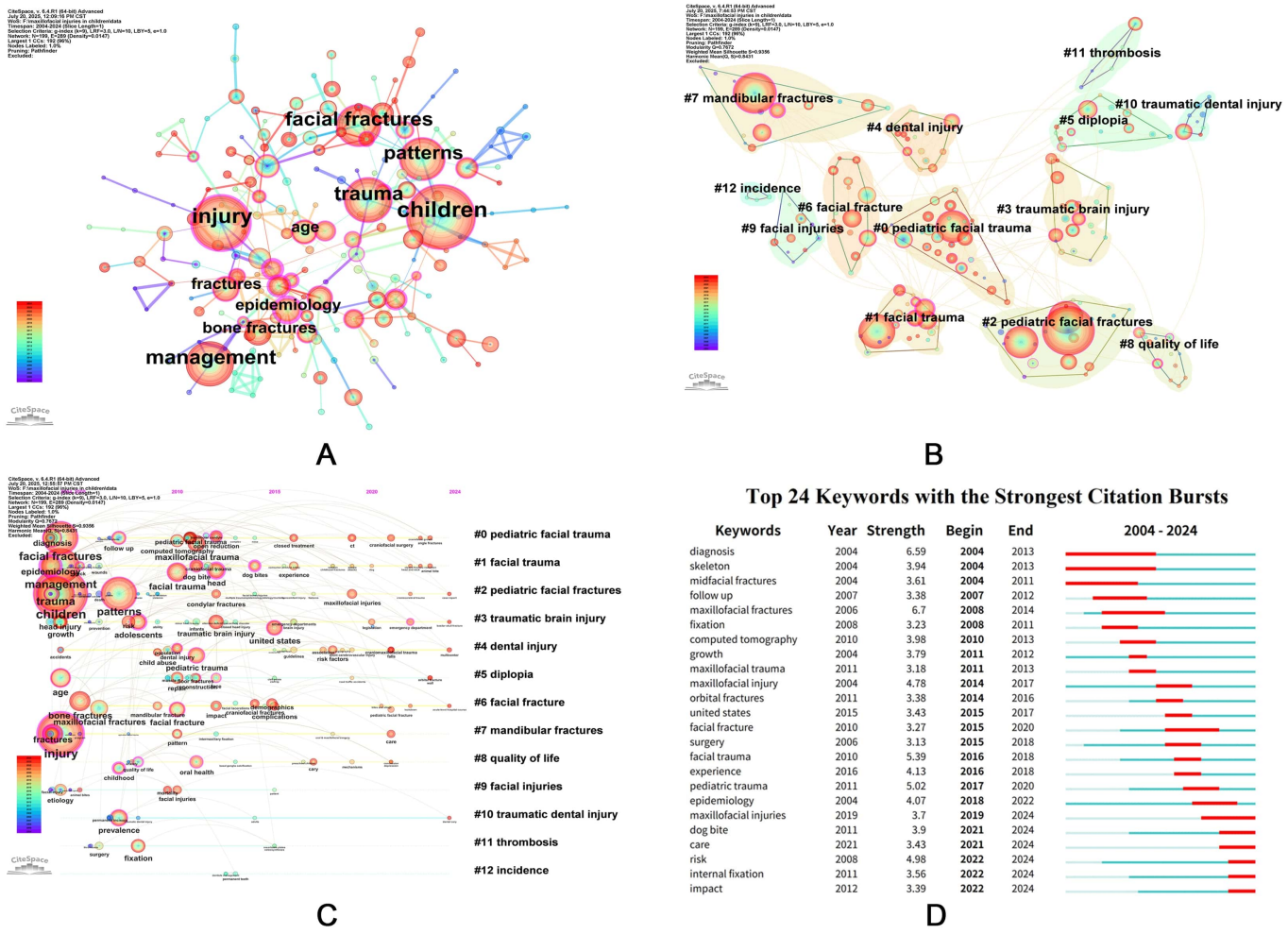


**FIGURE 3. Keyword current situation.** (A) The co-operation network of co-occurring keywords. (B) The network of co-occurring keywords clusters based on LLR algorithm. (C) Keyword timeline map. (D) The top 24 keywords with the strongest citation bursts. LRF, Link Retaining Factor; L/N, Links Per Node; LBY, Look Back Years; CCs, Connected Components.

**TABLE 3. The top 10 co-cited references sorted by the number of citations.**

| Rank | References | Citation count | Journal | Impact factor (2023) | Author | Year | Centrality |
|---|---|---|---|---|---|---|---|
| 1 | Pediatric Facial Fractures: Demographics, Injury Patterns, and Associated Injuries in 772 Consecutive Patients [14] | 25 | Plastic and Reconstructive Surgery | 3.20 | Grunwaldt L | 2011 | 0.48 |
| 2 | Pediatric Facial Trauma [15] | 25 | Clinics in Plastic Surgery | 1.80 | Andrew TW | 2019 | 0.36 |
| 3 | Pediatric Craniofacial Trauma [16] | 25 | Journal of Oral and Maxillofacial Surgery | 2.30 | Wymann NME | 2008 | 0.22 |
| 4 | Patterns and outcomes of pediatric facial fractures in the United States: a survey of the National Trauma Data Bank [17] | 22 | Journal of the American College of Surgeons | 3.80 | Imahara SD | 2008 | 0.39 |
| 5 | Pediatric facial fractures: recent advances in prevention, diagnosis and management [18] | 18 | International Journal of Oral and Maxillofacial Surgery | 2.20 | Zimmermann CE | 2006 | 0.17 |
| 6 | Management of Mandible Fracture in 150 Children Across 7 Years in a US Tertiary Care Hospital [19] | 17 | JAMA Facial Plastic Surgery | 4.67 | Kao R | 2019 | 0.25 |
| 7 | Differences in the Management of Pediatric Facial Trauma [20] | 16 | Seminars in Plastic Surgery | 2.30 | Braun TL | 2017 | 0.02 |
| 8 | Characteristics and age-related injury patterns of maxillofacial fractures in children and adolescents: a multicentric and prospective study [21] | 14 | Dental Traumatology | 2.30 | Segura-Palleres I | 2022 | 0.00 |
| 9 | Craniomaxillofacial trauma in children: a review of 3385 cases with 6060 injuries in 10 years [22] | 13 | Journal of Oral and Maxillofacial Surgery | 2.30 | Gassner R | 2004 | 0.14 |
| 10 | Analysis of pediatric maxillofacial trauma in North China: Epidemiology, pattern, and management [23] | 12 | Injury | 2.20 | Zhou W | 2020 | 0.03 |

### 3.3.2 Authors' co-citations analysis

Haug RH and Gassner R were the dominant contributors, in terms of total citation, to maxillofacial trauma in children research. In addition, the top 5 authors by betweenness centrality including Zimmermann CE, Haug RH, Iida S, Koltai PJ, and Andrew TW all had values greater than 0.2, which indicated that the published articles were highly significant in the field of maxillofacial trauma in children (Table 4, Fig. 4B).

### 3.3.3 Journal co-citations analysis

The Journal of Oral and Maxillofacial Surgery and the Plastic and Reconstructive Surgery were the core journals in this field, exhibiting the highest co-citation frequency. Additionally, among the top 10 co-cited journals, the centralities of the Journal of Cranio-Maxillofacial Surgery, the International Journal of Oral and Maxillofacial Surgery, Pediatrics, Archives of Otolaryngology-Head & Neck Surgery, Annals of Plastic Surgery, and Dental Traumatology all exceeded 0.1. This indicates that the articles published in these journals were highly significant in the field of maxillofacial trauma in children (Table 5, Fig. 4C).

## 4. Discussion

### 4.1 Research overview and publication landscape

This study used CiteSpace software to visualize and analyze 1018 children maxillofacial injuries-related literature from the WoSCC database. The study revealed a fluctuating upward trend in the number of articles published during the period from 2004 to 2024. In recent years there has been a rapid growth, especially the publication number of 2024 reached the peak, which indicated that the maxillofacial injuries in children have received much attention in recent years. The increase of literature in the recent 5 years may be related to the socio-economic environment, physical activity, lifestyle, and home

**TABLE 4. The top 10 co-cited authors sorted by the number of citations.**

| Rank | Cited author | Count | Centrality | Year |
|---|---|---|---|---|
| 1 | Haug RH | 155 | 0.62 | 2004 |
| 2 | Gassner R | 146 | 0.27 | 2006 |
| 3 | Imahara SD | 127 | 0.16 | 2010 |
| 4 | Zimmermann CE | 119 | 0.64 | 2006 |
| 5 | Ferreira PC | 109 | 0.08 | 2008 |
| 6 | Posnick JC | 95 | 0.22 | 2004 |
| 7 | Kaban LB | 80 | 0.11 | 2004 |
| 8 | Grunwaldt L | 77 | 0.06 | 2013 |
| 9 | Vyas RM | 69 | 0.00 | 2011 |
| 10 | Alcalá-Galiano A | 64 | 0.17 | 2011 |

**TABLE 5. The top 10 co-cited journals sorted by the number of citations.**

| Rank | Count | Cited journal | Centrality | Year |
|---|---|---|---|---|
| 1 | 501 | Journal of Oral and Maxillofacial Surgery | 0.02 | 2004 |
| 2 | 422 | Plastic and Reconstructive Surgery | 0.02 | 2004 |
| 3 | 399 | Journal of Craniofacial Surgery | 0.00 | 2004 |
| 4 | 307 | Journal of Cranio-Maxillofacial Surgery | 0.33 | 2004 |
| 5 | 294 | International Journal of Oral and Maxillofacial Surgery | 0.24 | 2004 |
| 6 | 287 | British Journal of Oral & Maxillofacial Surgery | 0.02 | 2004 |
| 7 | 269 | Pediatrics | 0.45 | 2004 |
| 8 | 265 | Oral Surgery Oral Medicine Oral Pathology Oral Radiology | 0.05 | 2004 |
| 9 | 240 | J Trauma | 0.08 | 2004 |
| 10 | 216 | Archives of Otolaryngology-Head & Neck Surgery | 0.35 | 2004 |

office of COVID-19 during lockdowns [24, 25].

Currently, the United States, India, and Brazil are leading in the field of pediatric maxillofacial injuries. Among them, the United States is the country with the highest number of articles, with 420 articles, accounting for 41.26% of the total 1018 articles. Its research in this field mainly involves pediatric facial fractures, pediatric facial soft tissue injuries, pediatric cranial firearm injuries, and so on [26–29]. It is worth noting that the top 11 high-publishing institutions and high-publishing authors are all from the United States. Among them, the Pennsylvania Commonwealth System of Higher Education (PCSHE) is particularly prominent, and the author with the most publications is Losee JE, who is the only author with 30 publications. It is evident that the United States has a significant lead in the field of maxillofacial injuries in children, and its influence in the global collaborative network in this area is of great importance. However, the mediating centrality, whether it is countries/regions, institutions, or authors, is less than 0.3. Thus, the study of maxillofacial injuries in children was relatively scattered, and there was a lack of cooperation between countries/Regions, institutions, and authors.

## 4.2 Key references and academic network

In co-cited references, Grunwaldt L (2011) [14], Andrew TW (2019) [15], and Wymann NME (2008) [16] were highly cited, which had a wide influence on maxillofacial trauma and fracture in children [14–16].

A study by Grunwaldt L *et al.* [14] analysed data on 772 children with facial fractures admitted to the emergency department of a paediatric level 1 trauma centre from 2000–2005 and found that male patients accounted for up to 68.9% of cases, that cranial fractures were more common in children $<10$ years of age, and that more than half of the patients (55.6%) were associated with serious concomitant injuries (especially craniocerebral injuries). In addition, fractures due to violence were significantly higher in males, older children, and low socioeconomic status groups. This study reveals the complex biosocial interaction mechanisms underlying facial fractures in children, suggesting the need for a comprehensive assessment in clinical practice. Attention should be paid to the socioeconomic impact on children's health to promote synergistic innovations in medical interventions and social support systems.

Andrew TW *et al.* [15] systematically described the clinical features and management strategies of facial trauma in

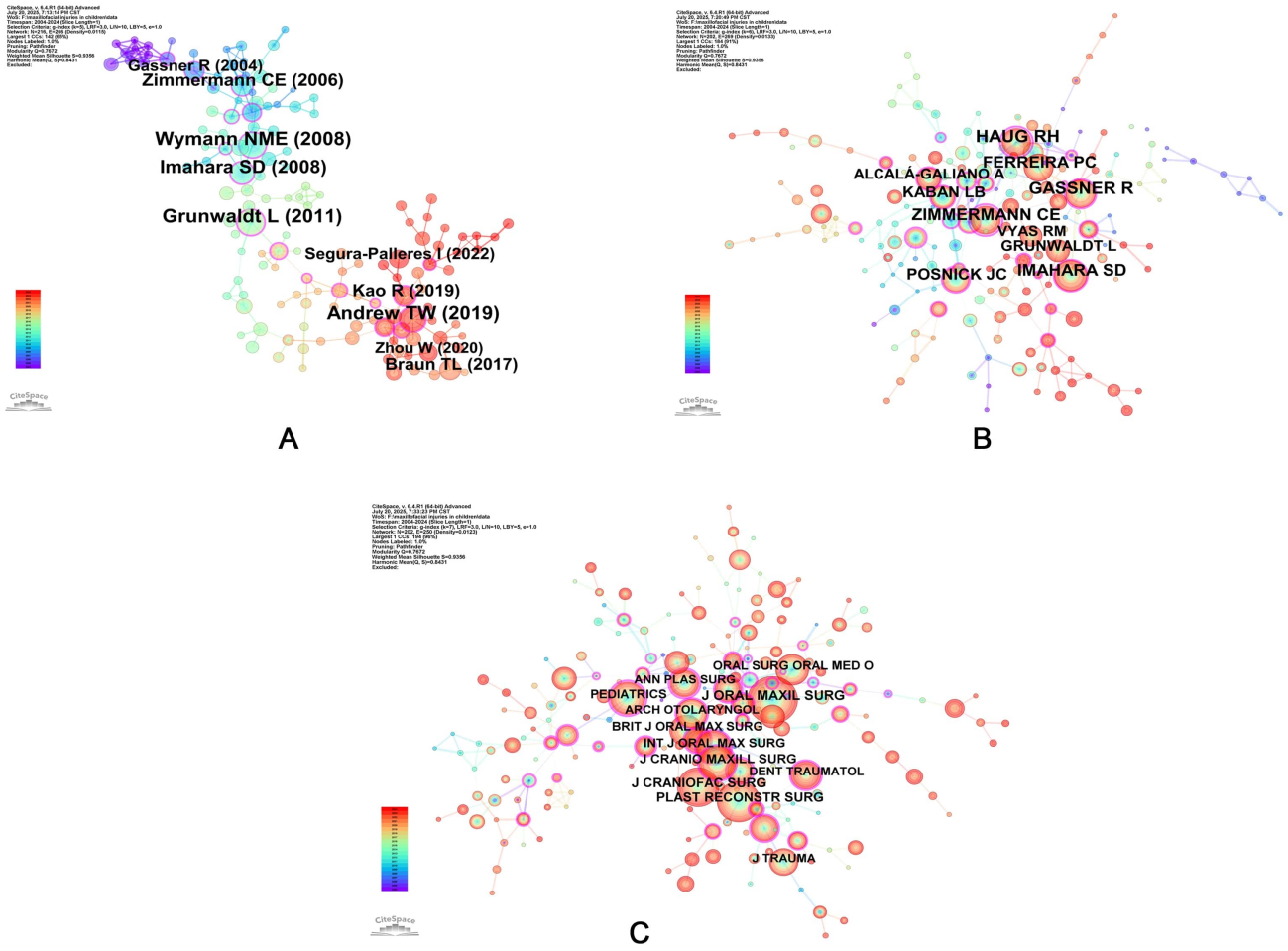


**FIGURE 4. Co-occurrence and co-citation graphs.** (A) The network of co-cited references. (B) The network of co-cited authors. (C) The network of co-cited journals. LRF, Link Retaining Factor; L/N, Links Per Node; LBY, Look Back Years; CCs, Connected Components.

children. The study noted that children have a significantly lower incidence of facial fractures than adults (predominantly glaucomatous fractures) due to anatomical features such as unmineralized bone, abundant fat pads, and under-pneumatized sinuses, but have a higher overall trauma incidence. The mechanism of injury was stratified by age: infants and toddlers had a predominance of falls (43.6%), while adolescents had a high prevalence of traffic accidents and violent injuries (25.3%). This study proposes the principle of graded treatment centred on the protection of growth. It stresses the need to strike a dynamic balance between trauma repair and growth potential in the management of maxillofacial trauma in children, which significantly improves individualized treatment of maxillofacial trauma in children.

A retrospective analysis of 291 cases of craniomaxillofacial trauma in children at a Swiss tertiary trauma centre by Wymann NME *et al.* [16] revealed a unique epidemiological profile of fractures in children. 52% of the children were aged 0–5 years, with a high prevalence of parietal fractures (54%) due to the large proportion of the cranial skeleton; 37% of fractures were located in the upper mid-face, and only 9% were in the lower jaw. Falls (64%) are the leading cause of injury (predominantly in young children), while traffic accidents (22%) and sports injuries (9%) are more common in adolescents. In addition, the rate of traffic injuries in Switzerland was significantly lower than in several studies in the United States (50%–65%), which is presumably related to the enforcement of speed limits and seatbelt penalties. This study provides key data on the age profile of childhood trauma and cross-cultural differences, which could be informative for optimizing paediatric trauma prevention and treatment strategies.

The co-citation analysis shows that Haug RH from the USA and Gassner R from Austria are highly influential authors in the field of paediatric maxillofacial trauma research. It demonstrates that their published literature is highly relevant in the field. The core journals in the field, Journal of Oral and Maxillofacial Surgery and Plastic and Reconstructive Surgery, have the highest co-citation frequency. Their impact factors in 2024 were 2.6 and 3.4, respectively. Despite the relatively low impact factor, their high brightness shows the significant value of published articles on maxillofacial injuries in children.

On all accounts, the quality of the research on maxillofacial injuries in children was not ideal. The highly cited literature was mainly comprised of investigation studies, and the influence indicators of the high-cited journals were all low. Therefore, we should enrich the research content and methods to improve research quality in the future.

### 4.3 Research hotspots and frontiers

High-frequency keywords and high mediator neutral keywords analysis results indicate that the current research hotspots in the field of pediatric maxillofacial injuries are children, injury, management, and trauma. The research focus areas in the area related to children are types of facial trauma and fracture types, injuries and complications associated with maxillofacial trauma, and the socioeconomic impact and epidemiology of maxillofacial injuries. According to Keyword Bursts analysis, the top 5 burst keywords are maxillofacial fracture, diagnosis, facial trauma, pediatric trauma, and risk. Emerging trends and research frontiers in current research topics include risk, internal fixation, and impact.

High-frequency keywords indicate popular topics within the research field, while high-center keywords reflect the status and influence of the relevant research content [13, 30]. We identified high-frequency keywords such as children, injury, management, trauma, and facial fracture, indicating that the studies primarily focused on the epidemiology and management of maxillofacial injuries in children.

Maxillofacial injuries were one of the most common diseases in the dental emergency department and needed more attention due to anatomical features. The key management of pediatric patients with maxillofacial injuries was airway management, and a detailed assessment was paramount [31–33]. In addition, the epidemiological factors of maxillofacial injuries in children varied in different countries or regions. In terms of the causes of injuries, most incidents in some Asian countries were due to falls at home or school, as well as traffic accidents. In contrast, injuries in European and American countries were predominantly caused by traffic accidents, sports-related incidents, and acts of violence [34–38].

However, the etiology and incidence of maxillofacial injuries changed greatly before and during COVID-19 pandemic, but there were relatively few studies involving pediatric patients [39–43]. The study of Kasem A *et al*. [40] showed that there was a decrease in maxillofacial fractures during the lockdown of 2020, and the largest share was among younger patients. Shenoi R *et al*. [41] conducted a retrospective study analyzing 349 cases of maxillofacial injuries in India, focusing on the periods before and during COVID-19 lockdowns (from October 2019 to August 2020). The study found that road traffic accidents (RTAs) decreased significantly from 72.50% pre-lockdown to 47.37% during the lockdown. However, RTAs rose to 63.83% after the lockdown ended. Additionally, injuries from falls increased from 22.50% to 31.58% during the lockdown. Notably, assaults surged sixfold, rising from 2.50% to 15.79% during this time, which was attributed to heightened instances of interpersonal violence (IPV) and domestic abuse. Following the lockdown, the percentage of assaults declined to 6.38%. The study revealed a male predominance in the injuries (81.1%) and indicated that young adults aged 21–30 years were the most affected demographic. This research underscores how pandemic-related restrictions influenced the nature of trauma cases, decreasing RTAs while increasing injuries related to IPV during confinement. The authors emphasize the need for coordinated prevention strategies to address these changing patterns. Therefore, the causes and patterns of maxillofacial injuries were a dynamic change process, as also observed in the timelines of co-citation clusters (Fig. 3C).

The result of the keyword clustering analysis showed that 13 tags were divided into three categories, namely classification of facial trauma and fracture types, injuries and complications associated with maxillofacial trauma, and the socioeconomic impact, epidemiology of maxillofacial injuries. In the past 20 years, the majority of topic clusters had been continuously studied except #8, #9, #11, and #12, which included socioeconomic impact, epidemiology, and outcomes *etc*. Among them, #0, #1, #2, #3, #4, topic clusters had deep connection with others, which was mainly related to the research scope of clusters (#0, #1, #2, #3, #4) and the difference in the definition of keywords by the authors. The results showed that epidemiology, risk factors, surgery, experience, management, and prevention always ran through most of clusters, but the studies were relatively unfocused. The maxillofacial fracture involved topic clusters #6 and #7, which was an important type of maxillofacial injury.

Facial fractures occurred in the frontal bone, the orbits, the nasal bone, the zygomatic bone, the maxilla, or the mandible [44]. Mandibular fractures were among the most common facial fractures in children, accounting for 20% to 50% of all pediatric facial fractures [45, 46]. Although facial fractures were less common in children than in adults [47, 48], pediatric facial fractures could result in skeletal deformities due to growth defects caused by these fractures. Therefore, prompt diagnosis and effective management were essential.

In addition, keyword burst analysis revealed that the terms “risk”, “internal fixation”, and “impact” gained increasing popularity in 2022, indicating that these three keywords will likely remain important areas of research in the field of pediatric maxillofacial injuries in the future. In conclusion, we should analyze the characteristics of maxillofacial injuries in children, and develop personalized treatment, management and prevention strategies in future studies.

## 5. Limitations

This study’s scope was limited to journal articles, excluding conference papers, dissertations, and books, which may have resulted in content gaps. Furthermore, analysis was restricted to WoSCC data visualized solely using CiteSpace, thus potentially excluding relevant publications from other databases. However, we further searched other databases for literature related to this field and found that the number and content of literature were consistent with WoSCC. In addition, the early publications had a high citation rate, while the recent publications were rarely cited. Therefore, trends demand a comprehensive dialectical assessment of this approach’s advantages and limitations versus traditional reviews.

## 6. Conclusions

This study analyzes the evolutionary trends and research hotspots of maxillofacial injuries in children using bibliometric analysis methods. The field has exhibited accelerated growth in recent years, with fluctuating yet rising publication volumes. The global research landscape for pediatric

maxillofacial injuries is dominated by the United States, which produced 41.26% (420/1018) of publications and hosts all the top 11 high-output institutions and authors (*e.g.*, PCSHE and Losee JE). Additionally, India and Brazil also emerged as significant contributors. Nevertheless, fragmented collaboration networks persist, evidenced by uniformly low mediating centrality metrics ($<0.3$) across countries, institutions, and authors, underscoring insufficient international and inter-institutional synergy.

Thematic evolution in pediatric maxillofacial injuries research reveals sustained priorities centered on epidemiological patterns, clinical management strategies emphasizing airway stabilization and growth-compatible surgical interventions for fractures, and socioeconomic determinants driving cross-cultural variations in injury incidence. Moreover, emerging frontiers, identified through keyword burst analysis, prioritize risk quantification of dynamic injury mechanisms, internal fixation techniques optimizing minimally invasive approaches, and multidimensional impact assessment integrating public policy interventions with health disparity mitigation, thus directing future research toward personalized prevention frameworks responsive to evolving environmental stressors. Future directions require enhanced global collaboration, longitudinal studies on post-traumatic growth outcomes, and personalized prevention strategies responsive to dynamic environmental factors.

## AVAILABILITY OF DATA AND MATERIALS

The datasets used and analyzed during the current study are available from the corresponding author on reasonable request.

## AUTHOR CONTRIBUTIONS

XLW, XRZ and YLS—designed the research study. XRZ, FL and YLS—performed the research. WQJ—provided help and advice on methodology validation and software development. XLW, XRZ and FL—analyzed the data. XLW and YLS—wrote the manuscript. All authors contributed to editorial changes in the manuscript. All authors read and approved the final manuscript.

## ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Not applicable.

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## CONFLICT OF INTEREST

The authors declare no conflict of interest.

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