



# Reconnoitering Trends and Patterns in the Research Landscape of Kumbh Mela in India: A Bibliometric Analysis since 2000

Ruchita Verma<sup>1</sup> , Dhanraj Sharma<sup>2</sup> \* and Navya Das<sup>3</sup>

<sup>1,2,3</sup> Department of Financial Administration, School of Management, Central University of Punjab,  
VPO. Ghudda, Distt. Bathinda, Punjab, India  
dhanrajsharma@cup.edu.in

**Abstract.** Kumbh Mela is the largest pilgrim gathering in India, with millions of people attending from different countries. This paper conducted a bibliometric analysis of Kumbh Mela literature for the time span of 2000 to 2024. It analyzed data from 163 publications retrieved from the Scopus and Web of Science databases using Biblioshiny and VOSviewer. This study was conducted to identify research trends, patterns of international collaboration, and to evaluate the emerging themes in research. The analysis reveals a notable growth in research publications between 2020 and 2024, with the majority of contributions coming from India, the United States, Australia, and the United Kingdom. Lecture Notes in Engineering recorded the highest number of publications, totaling six, while The Lancet received the most citations, with a count of 179. The Indian Institute of Science and the University of Sydney emerged as the leading institutions, each producing 16 publications. India not only contributed the largest share of publications but also showed the highest level of international collaboration. Among the keywords, “Kumbh Mela” was the most frequently cited by researchers. Keyword clustering identified crowd management and technology in mass gatherings as the emerging topics in the literature. The paper also developed a theme-wise content analysis of 30 curated articles using the TCCM framework.

**Keywords** Kumbh Mela, India, Bibliometric Analysis

## 1. Introduction

A pilgrimage is a journey that begins from the heart and is carried out with the feet, to meet a particular goal [54]. India, renowned for its rich spiritual, cultural, and traditional legacy, has hundreds of large and small pilgrimage spots that attract millions of devotees from

around the globe. Among the various religious congregations in India, the Kumbh Mela stands out as the largest pilgrimage gathering [42]. This religious gathering is celebrated on a particular day in the Hindu calendar, where millions of Hindu devotees come together to take a holy dip called “Snanam” [41]. Recognizing its importance, UNESCO, in its twelfth session held from December 4 to 9, 2017, in Jeju, South Korea, officially designated Kumbh Mela as an “Intangible Cultural Heritage of Humanity” [52].

The term Kumbh Mela originates from Sanskrit, where Kumbh refers to urn, and Mela signifies a gathering [11]. Often referred to as the “festival of the pitcher,” it involves the congregation of Hindu devotees and ascetics along the banks of sacred rivers on specific auspicious dates in the Hindu calendar [40]. According to Hindu mythology, the origins of the Kumbh Mela are rooted in a mythical conflict between the Devas (gods) and Asuras (demons) over amrita, the divine nectar of immortality. This celestial battle is believed to have lasted for 12 days and 12 nights [49]. While churning the primordial ocean of life (Ksheer Sagar), using Mount Mandara as the churning rod and the serpent Vasuki as the rope, a conflict arose between the Devas and Asuras over the precious nectar. Four droplets of the elixir fell at four different locations on Earth: Allahabad (Prayagraj), Ujjain, Nashik, and Haridwar [11]. The Kumbh Mela takes place in these four locations once every 12 years, with dates determined by astrological considerations. The Ardh Kumbh is organized at six-year intervals, while the Purna Kumbh takes place every twelve years. The rarest of all, the Maha Kumbh, is celebrated once every 144 years. One of the unique moments of Kumbh Mela is the Akhara’s Shahi Snans, called ‘royal baths,’ where ascetics carry weapons and symbols of royal authority [31]. The Mela takes place on the banks of rivers like the Ganga: Yamuna; Saraswati (Prayagraj), Godavari River (Nashik), Shipra River (Ujjain), and Ganga River (Haridwar) [1].

Kumbh Mela, as a globally recognized event, faces many complexities in planning and managing the event, as millions of devotees take part in it. Constructing a temporary city to accommodate millions of people is a challenging task [6]. In 2013, around 120 million people appeared the Kumbh Mela in Ahmedabad [8]. In the first 15 years of this century, stampedes resulted in the deaths of seven thousand people. Many people believe that these losses are the result of a lack of control and management [57]. Research has found that this mass assembling results in the spread of infectious diseases and viruses, posing a threat to humans and all living things, as viruses transmit through contaminated water [39], [25]. Kumbh Mela in 2021 resulted in an increase of 37 to 144 COVID-19 cases daily, which is about a 236% rise in Haridwar. In Uttarakhand, the number of daily cases rose from 138 to 480, while in India, total cases surged by 92%, from 45,600 to 92,754 per day during this period [46]. Numerous studies have been carried out on the socio-cultural, technological, and environmental aspects of Kumbh Mela, addressing the major challenges and suggesting more strategies to deal with various concerns.

The literature on kumbh Mela is an emerging area of study, as its popularity goes beyond national boundaries. People around the world, not just from India, come to attend and explore India's culture and traditions. This domain is multidisciplinary, covering a wide range of topics like crowd management, public health, environmental protection, technological development, and so on. Literature on Kumbh Mela provides a comprehensive framework to formulate policies to meet the logistical, cultural, technological, and environmental challenges of the event. To identify the existing literature on Kumbh Mela, this paper used bibliometric analysis, a tool commonly used to evaluate research performance [3]. The data is extracted from 163 papers from Scopus and Web of Science databases and analyzed using Biblioshiny and VOSviewer. It explores research trends within Kumbh Mela literature, highlighting key journals, documents, countries, and keywords. It also examines international collaboration on Kumbh Mela research and identifies emerging topics in the field of literature.

The structure of the paper is as follows: Section 2 provides a review of the relevant literature. Section 3 outlines the research methodology, while Section 4 presents the data analysis. The key findings are discussed in Section 5, and the study is concluded in Section 6.

## **2. Review of Literature**

Spirituality, deeply rooted in Indian civilization, is considered one of the oldest and most intrinsic determinants of health [38]. Pilgrimages have always served as a significant expression of spirituality and are often viewed as a classic method for shaping personal spirituality [21]. Although it does not ensure permanent transformation, it encourages individuals to adopt righteousness in their lives [48]. [34] examined the relationship between religiosity, happiness, and life satisfaction among pilgrims attending the Ardh-Kumbh Mela held in Prayag (Allahabad) in 2007. The Kumbh Mela fosters a sense of collective consciousness among participants, shaped through shared religious and spiritual experiences. The rituals performed during the event evoke a range of emotions that impact individual states of consciousness and also serve to strengthen social bonds, encouraging reconnection with others and the broader community [13].

As the largest human gathering in the world, the Kumbh Mela presents a significant challenge in terms of effective crowd management, ensuring safety, security, and surveillance, as millions of devotees attend the gathering every year [26]. [29] emphasized the need to study crowd behavior and its various applications, as stampedes have become a common phenomenon in mass gatherings. It is a complex task even for highly qualified and skilled public health experts to maintain the safety and security of lives [16]. High population density, unhygienic surroundings, and dangerous environmental pollutants lead to the sudden spread of pathogens [49]. Bodily waste products, including feces, sweat, spit,

urine, and vomit, contaminate the environment, causing dangerous diseases [44]. [40] discussed the rapid spread of COVID-19 during Kumbh Mela, which challenged the health care system. Many studies have been conducted on various strategies like onsite disease surveillance [1] and the use of mobile technology [30] to detect and respond to various outbreaks during Kumbh Mela. [5] analyzed the different phases of the event, such as infrastructure development and urban transformation of the host cities during previous Kumbh Mela events.

Research on Kumbh Mela is attaining greater significance, as there is a higher need to address the logistical and environmental concerns arising during the event. Kumbh Mela is a foundation of immense pride and a silent testament to the country's history [9]. Both national and international pilgrims visit temples, perform prostrations, and chant prayers, transforming the journey into a moment of increased consciousness and connection with the universe [12]. Numerous international studies have been conducted on Kumbh Mela, addressing public health challenges [44], crowd management [27], and other related areas, in collaboration with India. Hence, the literature on the Kumbh Mela holds global significance as it is a major attraction for international tourists. This paper employed bibliometric analysis, a method of quantitatively assessing research works [17]. It analyzes the trends in Kumbh Mela literature and identifies the key themes in the field. The paper also explores international collaborations and partnerships in Kumbh Mela literature using data retrieved from the Scopus and Web of Science bibliographic databases.

Main objectives of study are as follows:

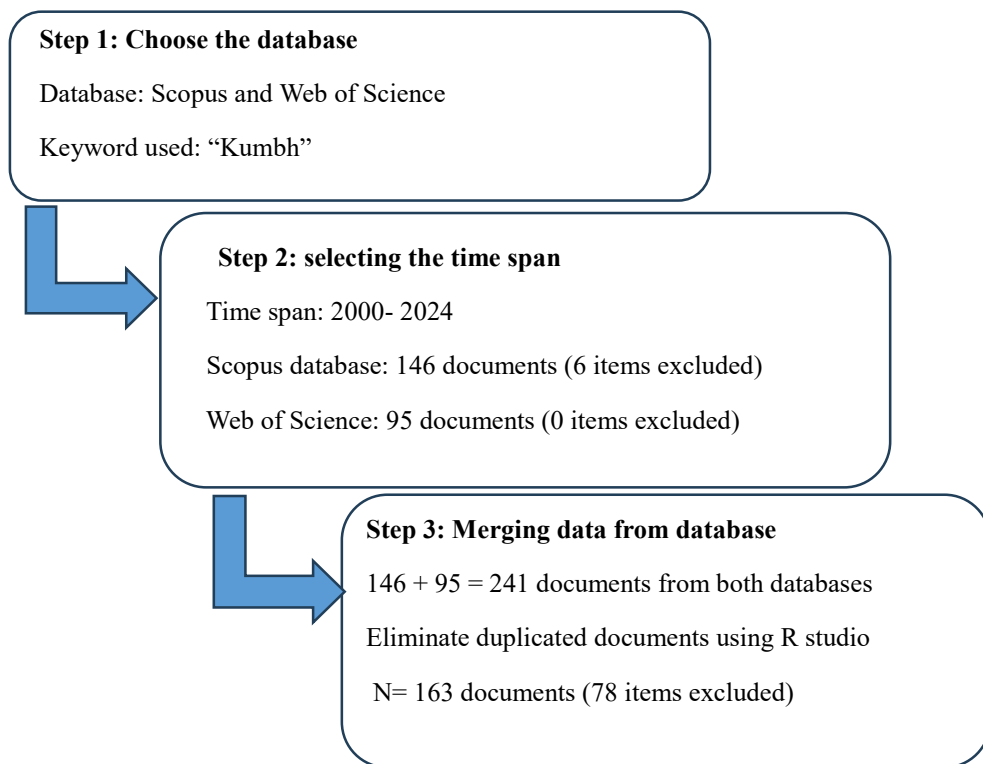
- a. To identify the trends in the literature on Kumbh mela.
- b. To examine patterns of international collaboration in the literature on Kumbh mela.
- c. To evaluate the significance of recurring themes in the literature on Kumbh mela.

### **3. Research Methodology**

The study employed bibliometric methods to analyze academic literature on the Kumbh for the period from 2000 to 2024. Bibliometric analysis is the quantitative examination of bibliographic materials, giving an overview of a research topic that can be grouped by papers, authors, and journals [37]. It helps to explore the evolutionary changes of a specific field, highlighting the growing trends within the field [14].

Data was collected from the Scopus and Web of Science indexing platforms, examining the most significant articles, key journals, leading countries, and rankings within the field. Using the keyword “Kumbh” for the time frame of 2000–2024, 146 documents were regained from Scopus and 95 documents from Web of Science in BibTeX format. Data related to authors, title, year, source, citation count, document type, DOI, affiliation,

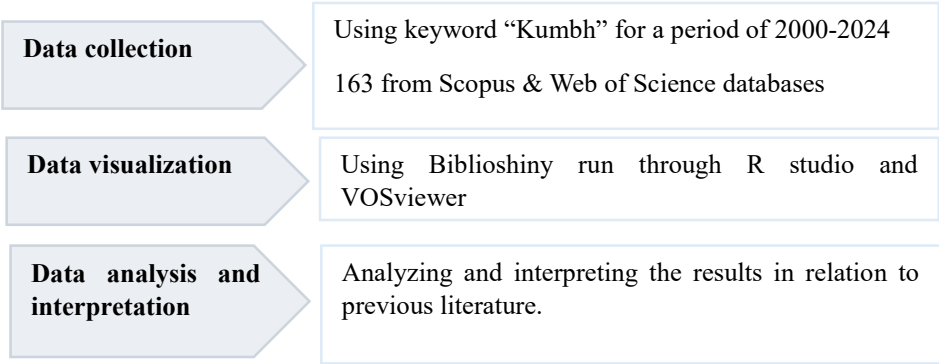
publisher, correspondence address, author keywords, abstract, language, and references were extracted from both databases. Since numerous papers are indexed in both Scopus and Web of Science, a straightforward aggregation of records from the two databases may lead to duplication and an inaccurate count. Therefore, duplicate entries were identified and removed using R Studio to ensure data accuracy, resulting in a total of 163 unique documents (Fig. 1).



**Fig. 1** Data Extraction

As shown in Fig. 2, this study was conducted in three stages: data collection, visualization, and analysis [43]. In the first stage, data was collected from the database of Scopus and Web of Science using the keyword "Kumbh" from 2000 to 2024. The datasets from both databases were merged, showing a total of 241 documents. This merged dataset was later refined by removing 78 duplicate items using R Studio, resulting in a final yield of 163 documents. In the second stage, this refined dataset was analyzed using Biblioshiny, run through R Studio, and visualized using VOSviewer to examine the relationships within the

bibliographic data. Finally, in the third stage, data was analyzed and interpreted by comparing it to previous literature, helping researchers identify trends, major themes, and evolutionary changes in the literature on Kumbh Mela.



**Fig. 2** Stages of Data Collection and Analysis

**4. Data Analysis**

The growth and trend in academic research on the Kumbh Mela have been analyzed in terms of various factors such as document types, yearly publications, most relevant journals, affiliations, countries, and keywords. A world collaboration map and co-authorship networks were constructed to assess the patterns of collaboration among researchers and institutions across different countries. A word cloud, co-occurrence network, and keyword clustering identify the most prevalent themes in the literature and help to determine their relevance or importance in the field of study.

**4.1 Overall growth of research on Kumbh**

This section examines the growth of scientific literature, analyzing the types of documents published, the yearly production trends, and the languages in which they are produced. It also discusses the multidisciplinary approach of researchers on Kumbh Mela, highlighting the different perspectives and contributions from various fields.

**Table 1** Document types

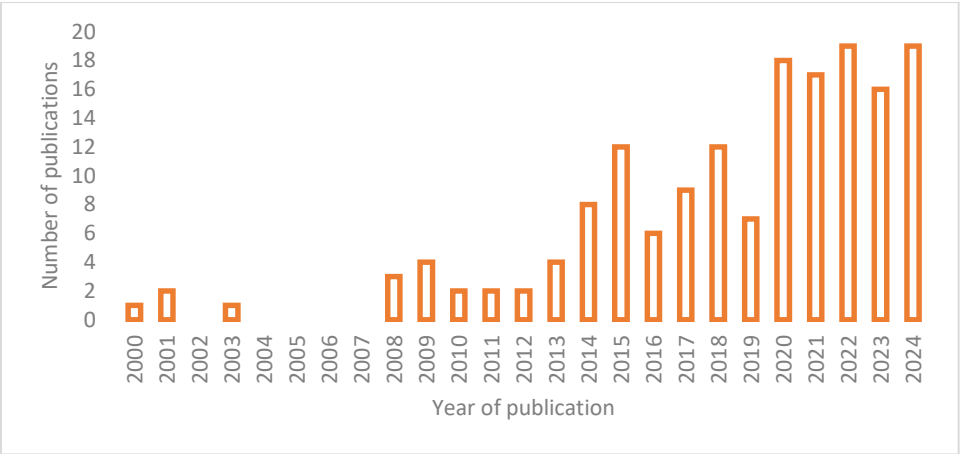
| Document type               | Number of documents | % of n (n=163) |
|-----------------------------|---------------------|----------------|
| Article                     | 94                  | 57.66          |
| Conference paper and review | 23                  | 14.11          |
| Review                      | 16                  | 9.81           |

|                    |    |      |
|--------------------|----|------|
| Book               | 14 | 8.58 |
| Editorial material | 7  | 4.29 |
| Letter             | 3  | 1.84 |
| Others             | 8  | 4.90 |

Table 1 shows the types of documents published in the database of Scopus and WoS from 2000 to 2024. Among 163 publications, 94 documents (57.66%) are articles, while only a lesser portion of the total documents are conference papers and reviews. They together constitute 23 documents (14.11%). There are 16 reviews (9.81%), 14 books (8.58%), 7 editorial materials (4.29%), 3 letters (1.84%), and the remaining 8 (4.90%) are other types of documents.

Most of the publications on Kumbh Mela are in three languages, with English being the most common. Around 98.77% of the documents are published in English, while one document each is published in Spanish and German (0.61%). No other languages have been used for these publications.

Kumbh research is interdisciplinary, as the literature is published across various academic fields. Different fields such as medicine, engineering, computer science, social sciences, arts and humanities, business & management, mathematics, and others have published scholarly journals on Kumbh Mela. This diversity in subject areas reflects the increased interest in Kumbh Mela across different professional and academic domains. However, there is a difference in the categorization of subject areas between Scopus and Web of Science databases, which makes data aggregation and analysis more difficult. It is challenging to compile the data into a single format as these databases use different classification methods and indexing techniques.



**Fig. 3** Annual Scientific Production

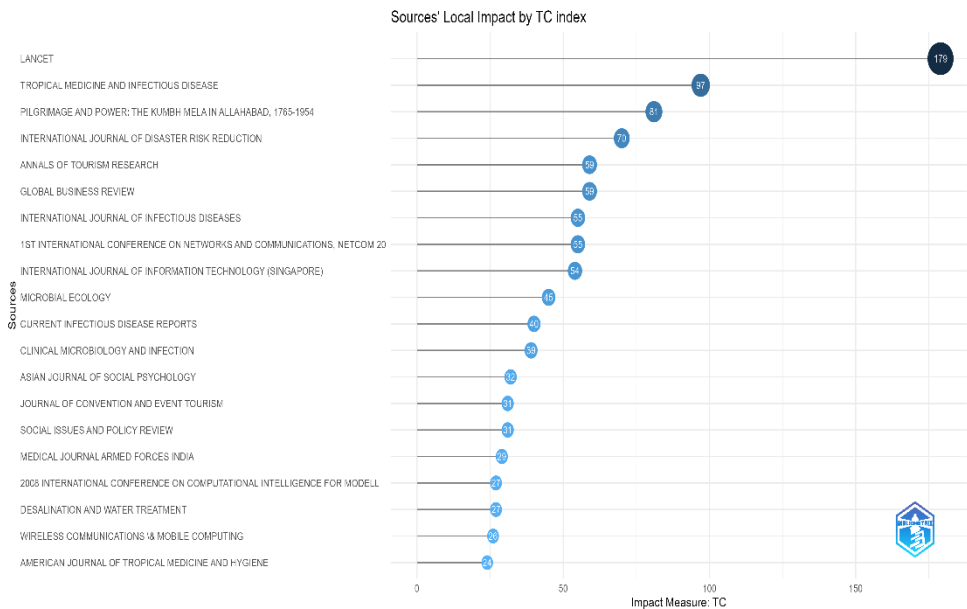
Fig. 3 displays the growth in quantity of publications on Kumbh Mela over the past few years. From 2000 to 2003, only a few papers were published on Kumbh Mela, which declined to no publications from 2004 to 2007. From 2008 onwards, the number of publications increased from 3 in 2008 to 12 in 2015 and continued to fluctuate in number until 2024. From 2020 to 2024, there was a sudden rise in the number of publications, with each year having a minimum of 16 publications. When the world was struck by the COVID-19 pandemic, many researchers focused on studying the impact of COVID on mass gatherings and how it contributed to the widespread transmission of diseases. This indicates the growing importance and significance of literature on Kumbh Mela since 2020.

4.2 Most relevant sources

Using Biblioshiny, the most relevant sources are identified based on the quantity of publications & citations, which will help scholars recognize the key journals contributing to the literature on Kumbh Mela.



Fig. 4 Top Twenty Journals Based on the Number of Publication

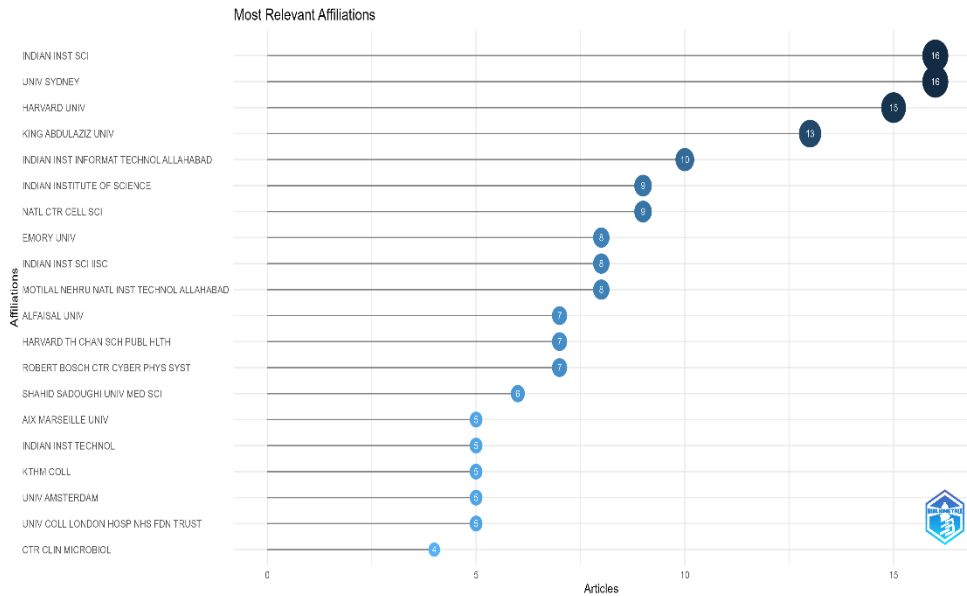


**Fig. 5** Top Twenty Journals by Maximum Number of Citations

As illustrated in Figure 4, Lecture Notes in Engineering leads with the highest number of publications (6), followed by the Journal of Travel Medicine with 5 publications. The International Journal of Infectious Diseases accounts for 4 publications, while the Indian Journal of Public Health, International Journal of Religious Tourism and Pilgrimage, and Multimedia Tools and Applications each contributed 3 publications, making them among the other prominent sources. In terms of citation impact (Figure 5), The Lancet ranks highest with 179 citations, followed by Tropical Medicine and Infectious Disease with 97 citations. The document titled Pilgrimage and Power: The Kumbh Mela in Allahabad, 1765–1954 stands out with 81 citations, surpassing several journals individually. The International Journal of Disaster Risk Reduction holds fourth place with 70 citations, while Annals of Tourism Research and Global Business Review are tied for fifth, each receiving 59 citations.

#### 4.3 Most Relevant Affiliation

This analysis helps the researchers to recognize the top 20 pertinent affiliation relating to the number of documents associated with Kumbh Mela.

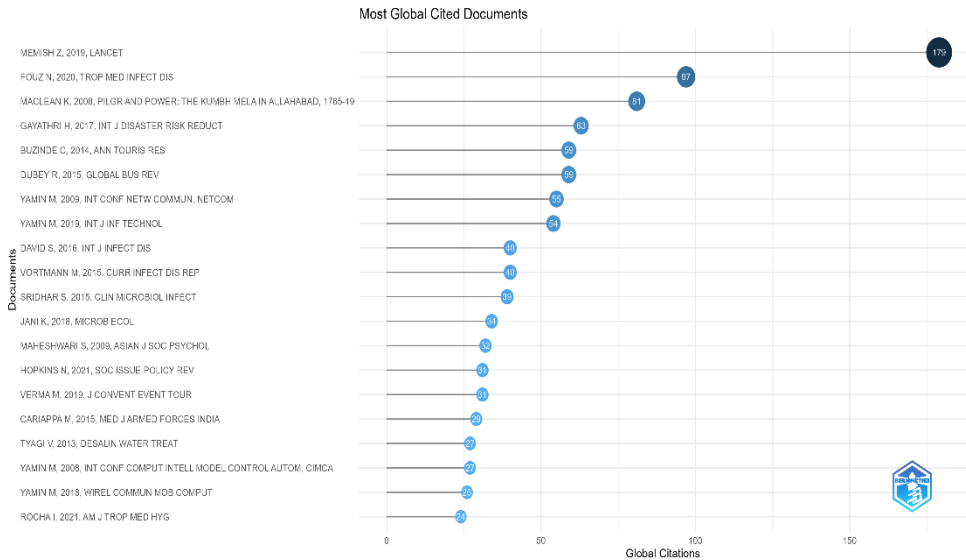


**Fig. 6** Top 20 Affiliations according to Number of Publication

The Indian Institute of Science (IISc) and University of Sydney lead with 16 documents each, showing their active research and contributions on this historical event. Harvard University published 15 documents, reflecting the rising global interest in Kumbh Mela. Following this, King Abdulaziz University published 13 documents, ensuring international scholarly contributions. The Indian Institute of Information Technology Allahabad (IIITA) has 10 documents, focusing primarily on the technological, logistical, regional, and local impacts of this event. This distribution depicts the growing academic interest in Kumbh Mela nationally and internationally across various disciplines.

**4.4 Most relevant documents**

Using Biblioshiny, documents are analyzed to recognize the key document having the highest number of citation count and cites per year.



**Fig. 7** Top 20 Globally Cited Documents

The plot graph was constructed to identify documents with the highest number of citations using Biblioshiny (Fig. 7). The most highly cited document is Mass Gatherings Medicine: Public Health Issues Arising from Mass Gathering Religious and Sporting Events [35], which has received 179 citations, with an average of 25.57 citations per year (Table 2). This is followed by The Contribution of Wastewater to the Transmission of Antimicrobial Resistance in the Environment: Implications of Mass Gathering Settings [19], which has garnered 97 citations and an annual average of 16.17. Pilgrimage and Power: The Kumbh Mela in Allahabad, 1765–1954 [33] has accumulated 81 citations, averaging 4.50 citations per year. The study A Review of Studies on Understanding Crowd Dynamics in the Context of Crowd Safety in Mass Religious Gatherings [20] has been cited 63 times, with an average of 7 citations per year. Other notable contributions include Emic Understandings of Kumbh Mela Pilgrimage Experiences [7] and Impact of Agility, Adaptability, and Alignment on Humanitarian Logistics Performance: Mediating Effect of Leadership, which also show significant academic engagement, though exact citation figures for the latter are not specified [15] are other top-ranked publications with 59 citations each. Although they have fewer citations per year, they are included among the top 10 relevant documents published on Kumbh Mela.

**Table 2** Top 10 Globally Cited Documents

| Rank | Authors                                                                                                        | Title                                                                                                                                       | Year | Cited by | Cites per year |
|------|----------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------|------|----------|----------------|
| 1    | Memish, Z. A., Steffen, R., White, P., Dar, O., Azhar, E. I., Sharma, A., & Zumla, A.                          | Mass gatherings medicine: public health issues arising from mass gathering religious and sporting events.                                   | 2019 | 179      | 25.57          |
| 2    | Fouz, N., Pangesti, K. N., Yasir, M., Al-Malki, A. L., Azhar, E. I., Hill-Cawthorne, G. A., & Abd El Ghany, M. | The contribution of wastewater to the transmission of antimicrobial resistance in the environment: implications of mass gathering settings. | 2020 | 97       | 16.17          |
| 3    | Maclean, K.                                                                                                    | Pilgrimage and power: the Kumbh Mela in Allahabad, 1765-1954.                                                                               | 2008 | 81       | 4.50           |
| 4    | Gayathri, H., Aparna, P. M., & Verma, A.                                                                       | A review of studies on understanding crowd dynamics in the context of crowd safety in mass religious gatherings.                            | 2017 | 63       | 7.00           |
| 5    | Buzinde, C. N., Kalavar, J. M., Kohli, N., & Manuel-Navarrete, D.                                              | Emic understandings of Kumbh Mela pilgrimage experiences.                                                                                   | 2014 | 59       | 4.92           |
| 6    | Dubey, R., Singh, T., & Gupta, O. K.                                                                           | Impact of agility, adaptability and alignment on humanitarian logistics performance: mediating effect of leadership.                        | 2015 | 59       | 5.36           |
| 7    | Yamin, M., & Ades, Y.                                                                                          | Crowd management with RFID and wireless technologies.                                                                                       | 2009 | 55       | 3.24           |
| 8    | Yamin, M.                                                                                                      | Managing crowds with technology: cases of Hajj and Kumbh Mela.                                                                              | 2019 | 54       | 7.71           |
| 9    | David, S., & Roy, N.                                                                                           | Public health perspectives from the biggest human mass gathering on earth: Kumbh Mela, India.                                               | 2016 | 40       | 4.00           |

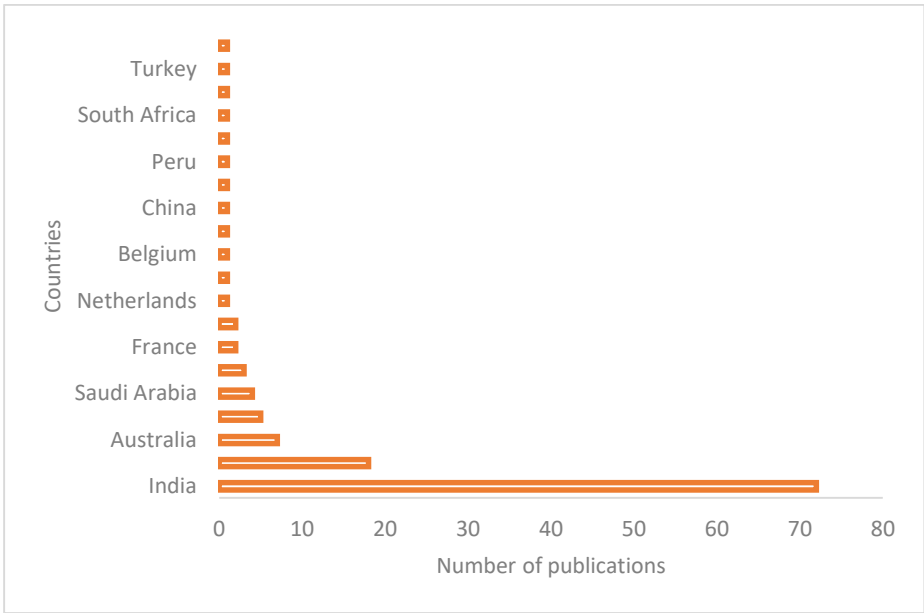
|           |                                                              |                                                                       |      |    |      |
|-----------|--------------------------------------------------------------|-----------------------------------------------------------------------|------|----|------|
| <b>10</b> | Vortmann, M., Balsari, S., Holman, S. R., & Greenough, P. G. | Water, sanitation, and hygiene at the world's largest mass gathering. | 2015 | 40 | 3.64 |
|-----------|--------------------------------------------------------------|-----------------------------------------------------------------------|------|----|------|

#### 4.5 Most Relevant Countries

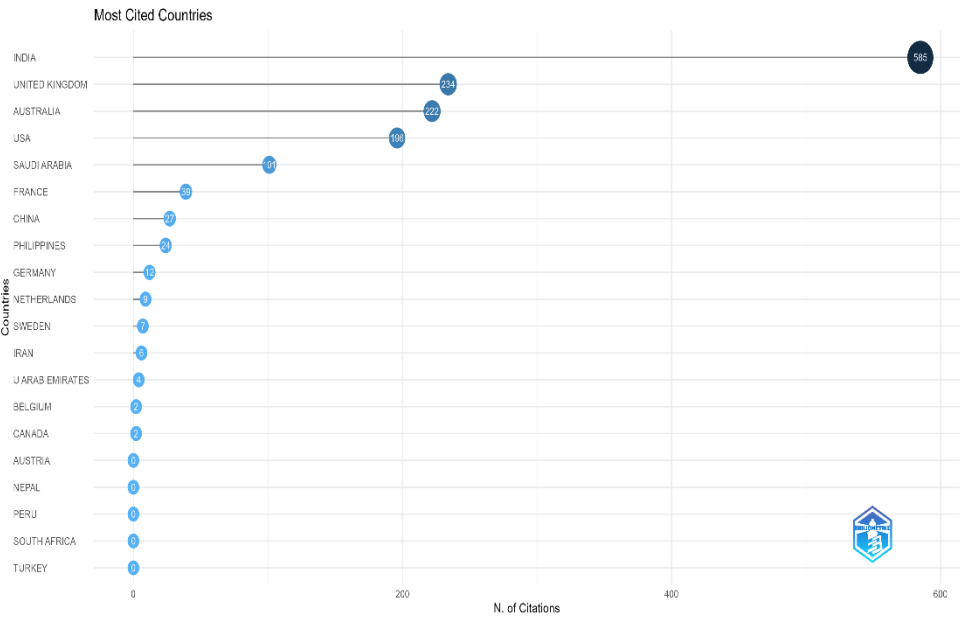
Although the Kumbh Mela is an event that represents India's culture, rituals, and traditions, research is being conducted in various parts of the world due to its global significance. This section identifies the countries with the maximum number of the publications and citations, along with their collaborations with other countries.

**Table 3** Countries with Number of Publication and Citations

| <b>Countries</b> | <b>No. of Documents</b> | <b>No. of citation</b> | <b>Countries</b> | <b>No. of documents</b> | <b>No. of citation</b> |
|------------------|-------------------------|------------------------|------------------|-------------------------|------------------------|
| India            | 72                      | 585                    | Belgium          | 1                       | 2                      |
| USA              | 18                      | 196                    | Canada           | 1                       | 2                      |
| Australia        | 7                       | 222                    | China            | 1                       | 27                     |
| United Kingdom   | 5                       | 234                    | Nepal            | 1                       | 0                      |
| Saudi Arabia     | 4                       | 101                    | Peru             | 1                       | 0                      |
| Germany          | 3                       | 12                     | Philippines      | 1                       | 24                     |
| France           | 2                       | 39                     | South Africa     | 1                       | 0                      |
| Iran             | 2                       | 6                      | Sweden           | 1                       | 7                      |
| Netherlands      | 2                       | 9                      | Turkey           | 1                       | 0                      |
| Austria          | 1                       | 0                      | UAE              | 1                       | 4                      |



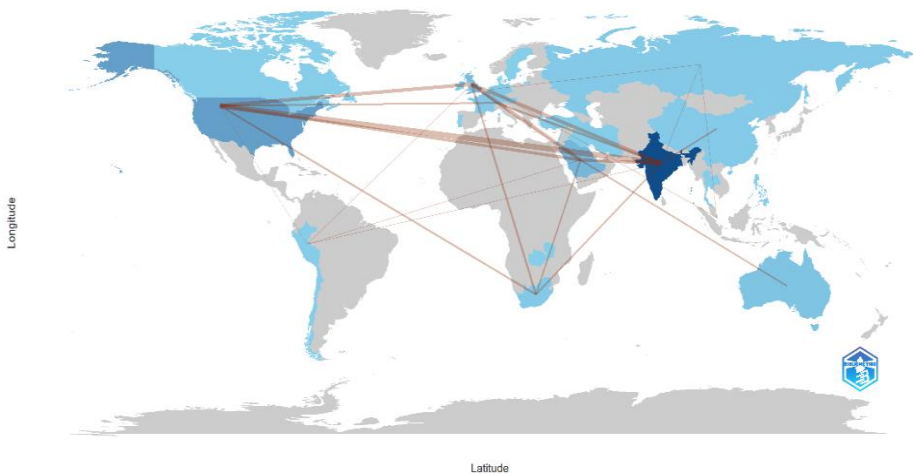
**Fig. 8** Countries with Highest Number of Publication



**Fig. 9** Most Cited Countries

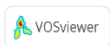
Fig. 8 highlights the 20 countries that have contributed to publishing research papers on Kumbh Mela. India is the top leading country with the maximum figure of 72 publications. United States of America (USA) ranks second with 18 publications, followed by Australia in third position (7 publications). Other countries like the United Kingdom, Saudi Arabia, and Germany have also contributed to academic research on Kumbh Mela with 5, 4, and 3 publications respectively. All other countries have limited publications, emphasizing the need for greater international involvement and awareness of the event. Similarly, in terms of the number of citations (Fig. 9), India ranks first with 585 citations, followed by the United Kingdom in second position with 234 citations, Australia in third position with 222 citations, and the USA in fourth rank with 196 citations. Although Saudi Arabia has a smaller quantity of citations (101 citations) as compared to India and other top countries, it is still included in the top 5 countries.

With 72 documents and 585 citations, India is the top country in context to number of publications and their citations (Table 3). The USA holds the second position in terms of publications and ranks fourth in citations. Australia is third in both publications and citations, while the United Kingdom ranks fourth for publications and second for citations. As the Kumbh Mela is the largest spiritual and religious gathering deeply rooted in India's customs, mythology, and social values, India's dominance in both is expected. Although Kumbh Mela has its origin in India, scholars throughout the world have contributed, crossing the limits of the country's borders. This shows that India's traditions, culture, and values are highly recognized and acknowledged, with increasing global interest in researching India's heritage.



**Fig. 10** Countries Collaboration Map

Fig. 10 shows the collaboration map of countries based on the magnitude of research on Kumbh Mela. The dark shaded regions represent areas with the highest contributions, while the light blue areas indicate countries with lesser contributions. India has the maximum number of publications, followed by the USA, which has slightly more collaboration than other countries. Light blue shaded areas like Australia, the United Kingdom, China, Peru, South Africa, and some other countries have less contribution, indicating that although there is international interest in Kumbh Mela, its reach is limited to certain regions and not widely spread across the world. This map helps to understand India’s position in research on Kumbh Mela and to identify emerging opportunities and collaborations around the globe.



**Fig. 11** Co-authorship between Countries

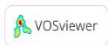
A network of co-authorship is created to visualize the collaboration between countries on scientific literature about Kumbh (Fig. 11). In the co-authorship network, each node represents a country, with node size reflecting the number of publications attributed to that country. The analysis was performed using VOSviewer, employing the full counting method and setting a minimum threshold of one publication. As some countries were not linked to others, the analysis focused on a connected subset of 32 items. These were grouped into 9 distinct clusters, comprising 104 links and a cumulative link strength of 183. India emerged as the most prolific contributor, with 104 publications, 25 collaborative links, and a total link strength of 61. The United States followed with 29 co-authored documents, 15 links, and a link strength of 49, with its strongest collaborative ties observed with India. This prominence is primarily because the Kumbh Mela is a cultural event of India and is held exclusively in India, leading to most collaborations being centered around the country.

#### 4.6 Most relevant keywords

Keywords are any textual elements that can consist of one or more words and function as either a common or proper noun [18]. They provide a precise summary of the document and help to arrange and access documents based on their content [47]. A word cloud is a tool that helps visualize the keywords used in the literature based on their number of occurrences.



It is found that “Kumbh Mela” is the most widely used author keyword, as it is the subject of the literature. “India” is the second most used keyword, representing the geographical significance of the studies. “Mass gathering,” “Kumbh,” “crowd,” and “crowd management” are some of the keywords highly used in the literature related to Kumbh Mela. Other frequently repeated keywords, such as “public health,” “pilgrimage,” and “mass religious gathering,” indicate the researchers’ multidisciplinary approach to studying the religious and cultural significance of Kumbh Mela.



**Fig. 13** Co-occurrence Network of Keywords

Keyword visualization presents the interconnections between various terms used in the literature, helping researchers identify major focus areas, links between terms, and emerging trends in the research [43]. Fig. 13 illustrates the graphical representation of the authors' keywords based on their frequency of occurrence and connections between the terms based on co-occurrence. Each node in the figure represents a keyword, and its size depends on the frequency of occurrence. Edges between the nodes show how the keywords are related to each other.

A visualization network of keywords was created using VOSviewer with a criterion of a minimum of two occurrences. Sixty-seven keywords that met the criteria are grouped into nine distinct clusters. “Kumbh Mela” has the highest frequency with 38 incidences, 36 links, and a link strength of 77. Following this, “India” has 20 occurrences, 20 links, and a total link strength of 46. “Mass gathering,” “Kumbh,” “crowd,” “crowd management,” and “public health” are a few other keywords with high numbers of links and link strength. This implies an increased focus by researchers on critical issues related to organizing large-scale events like Kumbh Mela.

**Table 4** Keyword Clustering

| Cluster No | Cluster label                                     | No. of items | Keywords                                                                                                                                                                                       |
|------------|---------------------------------------------------|--------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1          | Crowd management and Technology in Mass gathering | 11           | Computer vision, Convolutional Neural Network, crowd counting, crowd management, fog computing, location-based services, machine learning, mass religious gathering, RFID, security, stampedes |
| 2          | Agent based model and pedestrian                  | 9            | Agent based model, conflict, gap acceptance, gap forcing, gatherings, infectious diseases, mass, mass gatherings, pedestrian                                                                   |
| 3          | Public Health and Infectious Diseases             | 9            | 16s rRNA gene, antibiotic resistance, Covid-19, Godavari River, infectious disease, mass gathering event, motivation, public health, religious tourism                                         |
| 4          | Religious Pilgrimages                             | 9            | Allahabad, Ganga, Ganga River, Ganges, Kanwar yatra, Magh mela, pilgrimage, religion, Sangam                                                                                                   |
| 5          | Accessibility and safety                          | 9            | Accessibility, health, India, Kumbh, Mela, Mpox, prevention, risk assessment, safety                                                                                                           |
| 6          | Crowd Dynamics and Management                     | 8            | Anylogic, crowd, crowd dynamics, GIS, group behavior, management, mass religious gathering, stimulation                                                                                        |
| 7          | Sanitation and Environmental Concerns             | 5            | Mass gathering, sanitation, surveillance, water pollution, water quality                                                                                                                       |
| 8          | Covid-19 gatherings                               | 3            | Covid-19 pandemic, GSM, Kumbh mela                                                                                                                                                             |
| 9          | Pilgrimages                                       | 3            | Crowds, hajj, pilgrims                                                                                                                                                                         |

Keywords are classified into nine clusters based on their interconnections and occurrences. Each cluster is labeled with a specific name that best represents the keywords within that cluster. Cluster 1, labeled “Crowd Management and Technology in Mass Gatherings,” includes terms such as computer vision, convolutional neural network, crowd counting, fog computing, RFID, and security, highlighting the contribution of technology in crowd management at large events and mass gatherings. Cluster 2, named “Agent-Based Model

and Pedestrian,” contains terms like agent-based model, conflict, gap acceptance, gap forcing, gatherings, infectious diseases, mass, mass gatherings, and pedestrian, focusing on crowd dynamics and behaviors in mass gatherings.

Cluster 3, labeled “Public Health and Infectious Diseases,” contains nine keywords mainly concerning health issues in mass gatherings, especially infectious diseases. Cluster 4 deals with the religious and cultural aspects of mass gatherings, using terms such as Allahabad, Ganga, Ganga River, Ganges, Kanwar Yatra, Magh Mela, pilgrimage, religion, and Sangam. This cluster is thus named “Religious Pilgrimages.” Cluster 5 is labeled “Accessibility and Safety,” as it contains keywords related to safety, risk, and health during mass gatherings. Cluster 6 focuses on simulation tools and geographical information systems that help manage crowds at mass gatherings. Environmental and health aspects of mass gatherings are considered in Cluster 7. Similarly, Cluster 8 studies the effect of COVID-19 on mass gatherings, particularly the Kumbh Mela in India. Cluster 9 includes terms like Hajj and pilgrims, focusing on the religious aspects of mass gatherings. Although the keyword “Hajj” is not directly related to Kumbh Mela, it helps researchers compare the cultural, social, and logistical challenges that may arise in large-scale religious gatherings like Kumbh Mela and Hajj.

4.7 Thematic Diagram and Content Analysis

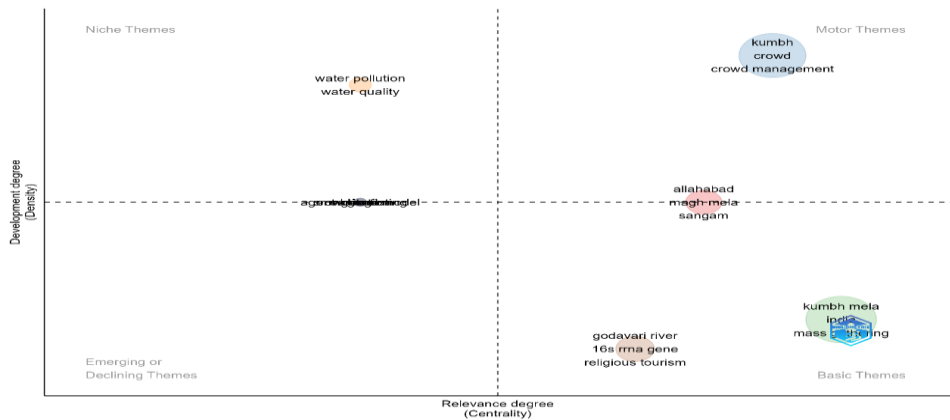


Fig. 14 Thematic Diagram

Fig. 14 presents a thematic diagram identifying the major themes in the existing literature on a two-dimensional grid. The map is separated into four quadrants, each demonstrating different themes classified based on density (degree of development) and centrality (degree of relevance). The first quadrant, located at the top right, demonstrates the motor themes—

those that are well developed and central to the field of study. This includes keywords such as Kumbh, crowd, and crowd management. The second quadrant, at the bottom right, presents the basic themes—important but less developed research areas. Keywords like Allahabad, Magh Mela, Sangam, Kumbh Mela, India, mass gathering, Godavari River, and religious tourism are among these basic themes. They form the core structure of existing literature but still offer opportunities for further exploration. The third quadrant, at the top left, includes themes that are well developed but less central to the study area, such as water pollution and water quality. Finally, the fourth quadrant, at the bottom left, shows new and emerging themes, with keywords like Ganga.

From the thematic diagram, the paper has derived three major themes:

- a. Kumbh mela and crowd management
- b. Mass gatherings and religious tourism.
- c. Water quality and health risks

Fig. 15 provides a thematic content analysis using the TCCM framework on 30 selected articles — the top 15 articles with the highest citations and the top 15 with the highest normalized citations, after removing overlaps (Fig. 8B). Each article is assigned to one of the themes, identifying the major theoretical foundations, contexts, key characteristics, and methodologies used in the literature. Since some articles fall under more than one theme, the exact number of articles per theme is not specified.

#### **a. Kumbh Mela and Crowd Management**

The biggest challenge faced by the Kumbh Mela is managing the massive crowd, as an uncontrolled influx of people floods the city during the event. Numerous studies have focused on crowd dynamics and management techniques aimed at preventing stampedes and loss of lives. [20] identified psychological factors influencing crowd behavior during mass gatherings, emphasizing the urgent need for crowd control measures and early warning systems to prevent crises like stampedes. [55] highlighted the risks of stampedes, inadequate crowd management, and the spread of infectious diseases during mass events such as Hajj and Kumbh Mela. Ritual practices like communal bathing and the lack of social distancing further upsurge the risk of disease transmission. Therefore, researchers have stressed the importance of strategic planning for crowd management, health monitoring, water and sanitation hygiene, and public awareness campaigns [40]. Additionally, [57] studied the implementation of RFID and wireless technologies to enhance crowd safety, minimize disaster impacts, and improve coordination among agencies.

#### **b. Mass Gatherings and Religious Tourism**

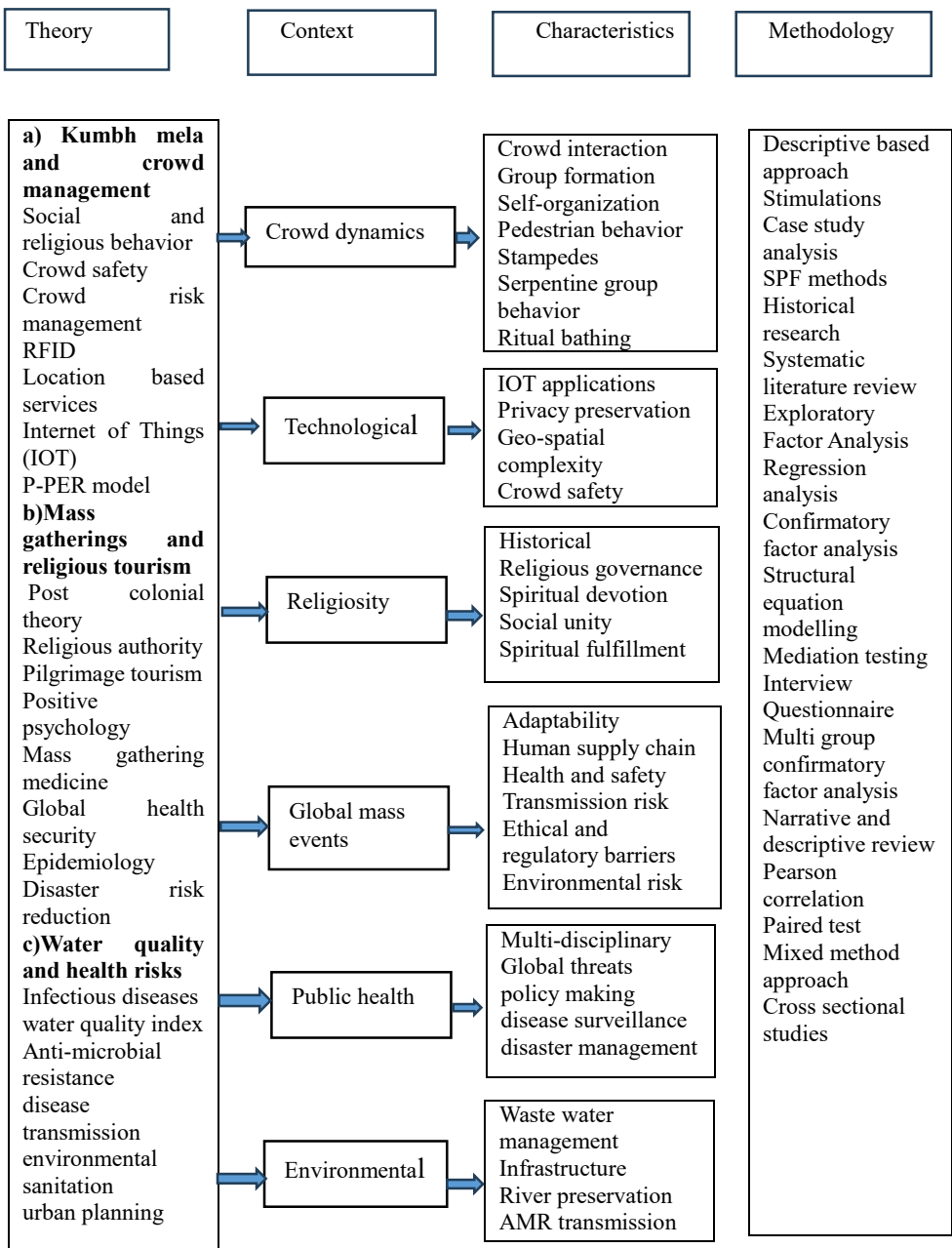
The second theme relates to mass gatherings and religious tourism, particularly pilgrimages. Research within this theme has focused on spiritual devotion and knowledge, highlighting the overlapping nature of religious tourism and spiritual practice [7]. Numerous studies have explored the socio-cultural and psychological aspects of religious events, examining how mass gatherings influence both individual and group behavior. These events serve as powerful platforms for strengthening social ties, expressing cultural identity, and fostering a sense of spiritual purpose and belonging. [34] explores the interplay between psychological variables—such as religiosity, happiness, and life satisfaction—within the frameworks of positive psychology and the psychology of religion. It also extends to global research addressing public health risks linked to mass gatherings, particularly the spread of infectious diseases and virus transmission [23].

### **c. Water Quality and Health Risks**

Water quality and management are major concerns during mass gatherings, especially large-scale religious events like the Kumbh Mela. [19] examined the role of wastewater in the transmission of antimicrobial resistance through environmental routes, providing a global comparison of various AMR models across different income settings and mass gatherings. [28] developed a Water Quality Index by integrating multiple parameters—such as scope, frequency, and amplitude—into a single score. Studies have also investigated the impact of large-scale human activities like communal bathing during events like the Kumbh Mela, which adversely affect the microbiological quality of natural water resources [51]. These factors pose significant threats to global health security, contributing to the spread of waterborne diseases, viral transmission, and infectious illnesses.

## **5. Findings and Discussion**

This paper examined the growth and trends in Kumbh Mela research over the past few decades using bibliometric analysis. The results indicate a notable increase in publications between 2020 and 2024, with the highest annual output of 19 documents in both 2022 and 2024. A total of 163 publications were extracted from the Scopus and WoS, of which 57.66% are articles. The remainder consists of conference papers, reviews, books, editorial materials, letters, and other document types. Publications are overwhelmingly in English (98.77%), with only one document each in German and Spanish.



**Fig. 15** TCCM of framework of Kumbh research

Research on Kumbh Mela spans multiple disciplines, including medicine, engineering, computer science, social sciences, arts and humanities, business & management, and mathematics. However, differences in classification and indexing methods between the two databases posed challenges for data aggregation and presentation in a unified format.

“Lecture Notes in Engineering” appeared as the foremost journal in terms of publication volume, with 6 documents, shadowed by the “Journal of Travel Medicine” with 5 publications. In terms of citations, The Lancet leads with 179 citations, followed by Tropical Medicine and Infectious Disease with 97 citations. The Indian Institute of Science (IISc) and the University of Sydney are the top contributing affiliations, each with 16 publications. The most influential document identified is “Mass gatherings medicine: public health issues arising from mass gathering religious and sporting events” [35], with 179 citations and an average of 25.57 citations per year.

To explore international collaboration patterns, the study analyzed country-wise production and citation data. India ranks first with 72 documents and 585 citations. Despite Kumbh Mela’s Indian origins, scholarly contributions have come from countries including the USA, Australia, the UK, Saudi Arabia, Germany, and France, reflecting growing global interest. A collaboration map shows India with the highest level of cooperation with other countries. Countries such as the USA, Australia, the UK, Peru, and South Africa show relatively fewer collaborations. The co-authorship network analysis reveals that India has 104 documents with co-authorship links to other countries, featuring 24 links and an entire link forte of 61, followed by the USA with 29 documents, 15 links, and a total link strength of 49.

The keyword co-occurrence network and clustering analysis help identify developing topics and thematic trends within the Kumbh Mela research field. The study found that “Kumbh mela” is the most frequently used author keyword, appearing 38 times and showing strong connections with other keywords. Keywords were grouped into 9 distinct clusters based on their frequency and interrelationships. The first cluster, labeled “Crowd Management and Technology in Mass Gatherings,” contains 11 keywords that emphasize the character of technology in crowd management during large-scale events. This paper delivers a comprehensive evaluation of the Kumbh Mela literature, highlighting gaps and opportunities for further research and development. A thematic diagram identified three major themes in the existing literature: Kumbh Mela and crowd management; mass gatherings and religious tourism; and water quality and health risks. Furthermore, the study developed a TCCM (Theory-Context-Characteristics-Methodology) framework to analyze 30 carefully selected articles, categorizing each according to one of the identified themes.

The study holds significant relevance to the management domain, particularly in areas such as event management, operations, logistics, public administration, tourism management, and cultural resource planning. Regarded as one of the most massive human gatherings worldwide, the Kumbh Mela, presents a complex ecosystem for studying large-scale event planning, crowd management, infrastructure development, crisis management, and stakeholder coordination. By conducting a bibliometric analysis, this study provides critical insights into how academic research has evolved around these managerial challenges and opportunities. The findings help identify which themes—such as sanitation logistics, digital governance, health services, or economic impacts—have gained scholarly attention and which remain underexplored, guiding future research agendas for management scholars. Furthermore, the study's methodological rigor in mapping influential authors, institutions, and collaboration networks serves as a reference for strategic academic partnerships and knowledge dissemination in management research. From a practical standpoint, understanding these research trends can inform public and private stakeholders involved in mega-event planning, enabling them to adopt evidence-based approaches and optimize resource utilization. The interdisciplinary nature of the research also reflects the convergence of technology, policy, and human behavior—key concerns in contemporary management studies. Thus, this paper contributes not only to bibliometric scholarship but also to applied management knowledge by situating Kumbh Mela as a dynamic field for testing theories of large-scale systems, coordination, innovation diffusion, and sustainable event management.

The study also provides practical recommendations for policymakers to address challenges associated with mass gatherings. Keyword co-occurrence networks and clustering reveal major themes in Kumbh Mela literature, such as crowd management, public health, water quality, sanitation, and surveillance. Numerous studies have explored technologies to enhance crowd control, ensure public safety, and mitigate the spread of infectious diseases. Policymakers can adopt these technological solutions—including AI, machine learning, and blockchain—to effectively manage the social, logistical, and environmental challenges of the event. For example, stampedes remain a critical risk, with a tragic incident in 2013 where thirty-six pilgrims lost their lives at the Allahabad railway station [22]. To prevent such disasters, policymakers should implement comprehensive disaster management strategies and promote research on mobile technologies, IP cameras, and social media platforms for real-time monitoring and crowd control [55].

## **6. Conclusion**

Kumbh Mela is undeniably a significant pilgrimage site that promotes religious tourism in India. This research generates meaningful insights to inform policy decisions and researchers to explore the multifaceted nature of religious pilgrimages, particularly Hindu

pilgrimages. It identified key journals such as *Lecture Notes in Engineering* and prominent institutions like the Indian Institute of Science (IISc) and the University of Sydney, providing researchers with guidance on relevant publication venues [10]. Approximately 44% of scholarly works are published in India. While Kumbh Mela is rooted in India, it attracts millions of international tourists, significantly contributing to global religious tourism. Therefore, policymakers should encourage academic engagement beyond India's borders by facilitating research fellowships and international partnerships. Given Kumbh Mela's deep cultural legacy, expanding international collaborations is crucial as global interest continues to grow. This paper advocates for increased interdisciplinary and cross-country cooperation on Kumbh Mela research.

Beyond policy, this study raises public awareness about Kumbh Mela from diverse perspectives. It frames the event not only as a religious and spiritual congregation but also as an international tourist attraction that fosters religious tourism. The literature clarifies government mechanisms and policies around crowd management, public health, urban planning, and security, thereby empowering local communities to improve infrastructure, transportation, and disaster preparedness. By conducting a bibliometric analysis of literature published from 2000 to 2024, the paper highlights key keywords, influential documents, leading institutions, and contributing countries to reveal trends, growth patterns, and collaboration networks. The findings underscore Kumbh Mela's global significance as a symbol of India's religious, spiritual, and cultural heritage, drawing millions of devotees worldwide. The study calls for greater interdisciplinary and international collaboration to comprehensively address challenges inherent in mass gatherings like Kumbh Mela. In particular, future research must prioritize crowd management and public safety, as incidents of stampedes have become more frequent. This paper contributes to a deeper understanding of emerging themes and provides strategic directions for managing the complexities of large-scale religious events.

## References

1. Aggrawal, V., Dikid, T., Jain, S. K., Pandey, A., Khasnobis, P., Choudhary, S., Singh, S. K.: Disease surveillance during a large religious mass gathering in India: The Prayagraj Kumbh 2019 experience. *International Journal of Infectious Diseases* **101**, 167-173 (2020)
2. Alqahtani, A. S., Alfelali, M., Arbon, P., Booy, R., Rashid, H.: Burden of vaccine preventable diseases at large events. *Vaccine*, **33**(48), 6552-6563 (2015)
3. Aria, M., Cuccurullo, C.: A brief introduction to bibliometrix. *Journal of Informetrics*, **11**(4), 959-975 (2017)
4. Balsari, S., Greenough, P. G., Kazi, D., Heerboth, A., Dwivedi, S., Leaning, J.: Public health aspects of the world's largest mass gathering: The 2013 Kumbh Mela in

- Allahabad, India. *Journal of public health policy*, **37**, 411-427 (2016)
5. Bansal, A., Plan, M., Arch, B.: Mega Events as Catalyst for Urban Transformation-A Case of Kumbh Mela in Ujjain. *Academia. edu*–Share research, (2013)
  6. Baranwal, A., Anand, A., Singh, R., Deka, M., Paul, A., Borgohain, S., Roy, N.: Managing the earth's biggest mass gathering event and wash conditions: Maha kumbh mela (India). *PLoS currents*, **7**, (2015)
  7. Buzinde, C. N., Kalavar, J. M., Kohli, N., Manuel-Navarrete, D.: Emic understandings of Kumbh Mela pilgrimage experiences. *Annals of Tourism Research*, **49**, 1-18 (2014)
  8. Cariappa, M. P., Singh, B. P., Mahen, A., Bansal, A. S.: Kumbh Mela 2013: Healthcare for the millions. *medical journal armed forces India*, **71**(3), 278-281 (2015)
  9. Chauhan, A.: The mystic kumbh mela from mythology to reality. *Voice of Intellectual Man-An International Journal*, **1**(1), 79-90 (2011).
  10. Das, A., Kondasani, R. K. R., Deb, R. Religious tourism: a bibliometric and network analysis. *Tourism Review*, **79**(3), 622-634 (2024)
  11. David, S., Roy, N.: Public health perspectives from the biggest human mass gathering on earth: Kumbh Mela, India. *International Journal of Infectious Diseases*, **47**, 42-45 (2016)
  12. Divya, B. R.: Review study of kumbh mela as a pilgrimage site. *Yoga Mimamsa*, **52**(2), 88-95 (2020)
  13. Divya, B. R., Murthy, K.: Exploring the collective consciousness fields of Ardha Kumbh Mela 2019. *Journal of Health Research and Reviews (In Developing Countries)*, **7**(1), 36-41(2020)
  14. Donthu, N., Kumar, S., Mukherjee, D., Pandey, N., Lim, W. M.: How to conduct a bibliometric analysis: An overview and guidelines. *Journal of business research*, **133**, 285-296 (2021)
  15. Dubey, R., Singh, T., Gupta, O. K.: Impact of agility, adaptability and alignment on humanitarian logistics performance: mediating effect of leadership. *Global Business Review*, **16**(5), 812-831 (2015)
  16. Dwivedi, S., Cariappa, M. P.: Mass-gathering events: the public health challenge of the Kumbh Mela 2013. *Prehospital and disaster medicine*, **30**(6), 621-624 (2015)
  17. Ellegaard, O., Wallin, J. A.: The bibliometric analysis of scholarly production: How great is the impact?. *Scientometrics*, **105**, 1809-1831 (2015)
  18. Firoozeh, N., Nazarenko, A., Alizon, F., Daille, B.: Keyword extraction: Issues and methods. *Natural Language Engineering*, **26**(3), 259-291 (2020)
  19. Fouz, N., Pangesti, K. N., Yasir, M., Al-Malki, A. L., Azhar, E. I., Hill-Cawthorne, G. A., Abd El Ghany, M.: The contribution of wastewater to the transmission of antimicrobial resistance in the environment: implications of mass gathering settings. *Tropical*

- medicine and infectious disease, **5**(1), 33 (2020)
20. Gayathri, H., Aparna, P. M., Verma, A.: A review of studies on understanding crowd dynamics in the context of crowd safety in mass religious gatherings. *International journal of disaster risk reduction*, **25**, 82-91 (2017)
  21. Greenia, G. D.: What is pilgrimage?. *International Journal of Religious Tourism and Pilgrimage*, **6**(2), 3 (2018).
  22. Greenough, P. G.: The Kumbh Mela stampede: disaster preparedness must bridge jurisdictions. *BMJ*, **346** (2013)
  23. Hopkins, N., Reicher, S.: Mass Gatherings, health, and Well-Being: from risk mitigation to health promotion. *Social Issues and Policy Review*, **15**(1), 114-145 (2021)
  24. Kamath, V., Ribeiro, M. A., Woosnam, K. M., Mallya, J., Kamath, G.: Determinants of visitors' loyalty to religious sacred event places: A multigroup measurement invariance model. *Journal of travel research*, **62**(1), 176-196 (2023)
  25. Kanaujiya, A. K., Tiwari, V.: Crowd management and strategies for security and surveillance during the large mass gathering events: The Prayagraj Kumbh Mela 2019 Experience. *National Academy science letters*, **45**(3), 263-273 (2022)
  26. Kanaujiya, A. K., Tiwari, V. The statistical analysis to find correlation between mass gathering event and COVID-19 pandemic outbreak: the Prayagraj Magh Mela 2021 experience. *Proceedings of the National Academy of Sciences, India Section A: Physical Sciences*, **93**(1), 107-111 (2023).
  27. Kanaujiya, A. K., Tiwari, V.: Health implications of mass gatherings: Kumbh Mela in India 2025. *Journal of Travel Medicine*, **31**(6), (2024)
  28. Kanaujiya, A. K., Tiwari, V.: Water quality analysis of River Ganga and Yamuna using water quality index (WQI) during Kumbh Mela 2019, Prayagraj, India. *Environment, Development and Sustainability*, **26**(2), 5451-5472 (2024)
  29. Karthika, P. S., Aparna, P. M., Verma, A.: Understanding crowd dynamics at ghat regions during world's largest mass religious gathering, Kumbh Mela. *International journal of disaster risk reduction*, **31**, 918-925 (2018)
  30. Ka zi, D. S., Greenough, P. G., Madhok, R., Heerboth, A., Shaikh, A., Leaning, J., Balsari, S.: Using mobile technology to optimize disease surveillance and healthcare delivery at mass gatherings: a case study from India's Kumbh Mela. *Journal of Public Health*, **39**(3), 616-624 (2017)
  31. Lochtefeld, J. G.: The construction of the Kumbha Mela. *South Asian Popular Culture*, **2**(2), 103-126 (2004).
  32. Jani, K., Dhotre, D., Bandal, J., Shouche, Y., Suryavanshi, M., Rale, V., Sharma, A.: World's largest mass bathing event influences the bacterial communities of Godavari, a holy river of India. *Microbial ecology*, **76**, 706-718 (2018)

33. Maclean, K.: Pilgrimage and power: the Kumbh Mela in Allahabad, Oxford University Press. 1765-1954 (2008)
34. Maheshwari, S., Singh, P.: Psychological well-being and pilgrimage: Religiosity, happiness and life satisfaction of Ardh-Kumbh Mela pilgrims (Kalpvasis) at Prayag, India. *Asian Journal of Social Psychology*, **12**(4), 285-292 (2009)
35. Memish, Z. A., Steffen, R., White, P., Dar, O., Azhar, E. I., Sharma, A., Zumla, A.: Mass gatherings medicine: public health issues arising from mass gathering religious and sporting events. *The Lancet*, **393**(10185), 2073-2084 (2019)
36. Memish, Z. A., Zumla, A., Parker, S.: Heat-related deaths during the 2024 Hajj pilgrimage. *Journal of travel medicine*, **31**(6) (2024)
37. Merigó, J. M., Yang, J. B.: A bibliometric analysis of operations research and management science. *Omega*, **73**, 37-48 (2017)
38. Mishra, B., Baghel, A. S., Paliwal, D., Chauhan, D. S.: Study of spiritual health determinants in Indian saints (sadhus) at Ujjain Kumbh Mela (Simhast) 2016. *Journal of religion and health*, **59**, 1233-1257 (2020)
39. Patel, A. K., Mukherjee, S., Leifels, M., Gautam, R., Kaushik, H., Sharma, S., Kumar, O.: Mega festivals like MahaKumbh, a largest mass congregation, facilitated the transmission of SARS-CoV-2 to humans and endangered animals via contaminated water. *International Journal of Hygiene and Environmental Health*, **237**, 113836 (2021)
40. Quadri, S. A., Padala, P. R.: An aspect of Kumbh Mela massive gathering and COVID-19. *Current Tropical Medicine Reports*, **8**, 225-230 (2021)
41. Rocha, I. C. N., Pelayo, M. G. A., Rackimuthu, S.: Kumbh mela religious gathering as a massive superspreading event: Potential culprit for the exponential surge of COVID-19 cases in India. *The American Journal of Tropical Medicine and Hygiene*, **105**(4), 868 (2021)
42. Saha, K., Khare, R.: A geospatial approach to conserving cultural heritage tourism at Kumbh Mela events in India. In *Tourism, Cultural Heritage and Urban Regeneration: Changing Spaces in Historical Places* (pp. 125-140). Cham: Springer International Publishing (2020)
43. Sari, Q. I. P.: Bibliometric Analysis of Child Marriage Issues in Scopus and WoS Databases (1999-2024). *ARISTO*, **13**(2), 340-360 (2024)
44. Sharma, A., Gupta, B., Petersen, E., Lee, S. S., Zumla, A.: Enhancing preparedness for reducing transmission and globalisation of Antimicrobial Resistance at the Ardh Kumbh Mela 2025, the world's largest recurring religious mass gathering. *International Journal of infectious diseases*, **137**, 79-81 (2023)
45. Sharma, A., Rodriguez-Morales, A. J., Srivastava, S., Memish, Z. A., Zumla, A.: Public Health Challenges at the Upcoming Kumbh Mela 2025: Addressing the Mpox global

- public health emergency of international concern. *Travel medicine and infectious disease*, 102771 (2024)
46. Shukla, S., Khan, R., Ahmed, Y., Memish, Z. A.: Conducting mass gathering events during the COVID-19 pandemic: a case study of Kumbh Mela 2021 as a potential ‘super spreader event’. *Journal of Travel Medicine*, **28**(8), (2021)
  47. Siddiqi, S., Sharan, A.: Keyword and keyphrase extraction techniques: a literature review. *International Journal of Computer Applications*, **109**(2) (2015)
  48. Singh, A., Malik, S., Sharma, K. D.: Deconstructing the Spurious Belief System behind Pilgrimage: Enlightening Youth towards Spirituality. (2021)
  49. Sridhar, S., Gautret, P., Brouqui, P. A.: comprehensive review of the Kumbh Mela: identifying risks for spread of infectious diseases. *Clinical microbiology and Infection*, **21**(2), 128-133 (2015)
  50. Subramanian, G. H., Choubey, N., Verma, A.: Modelling and simulating serpentine group behaviour in crowds using modified social force model. *Physica A: Statistical Mechanics and its Applications*, **604**, 127674 (2022)
  51. Tyagi, V. K., Bhatia, A., Gaur, R. Z., Khan, A. A., Ali, M., Khursheed, A., ... Lo, S. L.: Impairment in water quality of Ganges River and consequential health risks on account of mass ritualistic bathing. *Desalination and Water Treatment*, **51**(10-12), 2121-2129 (2013)
  52. Verma, M., Sarangi, P.: Modeling attributes of religious tourism: A study of Kumbh Mela, India. *Journal of Convention & Event Tourism* **20**(4), 296-324 (2019)
  53. Vortmann, M., Balsari, S., Holman, S. R., Greenough, P. G.: Water, sanitation, and hygiene at the world’s largest mass gathering. *Current infectious disease reports*, **17**, 1-7 (2015)
  54. Yadav, D., Mahato, S., Choudhary, A., Joshi, P. K. Cultural heritage and urban morphology: land use transformation in ‘Kumbh Mela’ of Prayagraj, India. *Frontiers of Urban and Rural Planning*, **2**(1), 8 (2024)
  55. Yamin, M.: Managing crowds with technology: cases of Hajj and Kumbh Mela. *International journal of information technology*, **11**(2), 229-237 (2019)
  56. Yamin, M., Abi Sen, A. A.: A new method with swapping of peers and fogs to protect user privacy in IoT applications. *IEEE Access*, **8**, 210206-210224 (2020)
  57. Yamin, M., Ades, Y.: Crowd management with RFID and wireless technologies. In 2009 First International Conference on Networks & Communications. 439-442. IEEE, (2009)

**Open Access** This chapter is licensed under the terms of the Creative Commons Attribution-NonCommercial 4.0 International License (<http://creativecommons.org/licenses/by-nc/4.0/>), which permits any noncommercial use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons license and indicate if changes were made.

The images or other third party material in this chapter are included in the chapter's Creative Commons license, unless indicated otherwise in a credit line to the material. If material is not included in the chapter's Creative Commons license and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder.

