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A Bibliometric Analysis of Drone Technology in Healthcare Logistics

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ABSTRACT

The integration of drone technology into healthcare logistics has emerged as a strategic innovation to enhance the speed, accessibility, and resilience of medical supply chains, particularly in emergency and remote settings. Despite rapid technological progress, the intellectual structure and global research dynamics of this domain remain fragmented and insufficiently synthesized. This study conducts a comprehensive bibliometric analysis to map the evolution, thematic structure, and collaborative landscape of drone technology in healthcare logistics. Bibliographic data were retrieved from the Scopus database and refined through systematic screening, yielding 830 peer-reviewed journal articles published between 2016 and 2025. Data cleaning was performed using OpenRefine, while performance analysis and science mapping were conducted using the Scopus analyzer and VOSviewer. The findings reveal exponential publication growth, with more than 60% of outputs produced in the most recent 4 years. The United States, India, and China lead in productivity, while emergency medical services, unmanned aerial vehicles, and Internet of Things emerge as dominant research themes. The results demonstrate a rapidly consolidating, interdisciplinary field with strong international collaboration, highlighting its expanding role in advancing resilient, intelligent healthcare logistics systems.

Keywords: Bibliometric analysis, Drone, Emergency medical services, Healthcare, Unmanned Aerial Vehicle (UAV).

1. INTRODUCTION

The integration of drone technology into healthcare logistics represents a transformative advancement with the potential to significantly enhance the efficiency, speed, and reliability of medical supply delivery. This innovation is particularly crucial in addressing the logistical challenges posed by traffic congestion, geographical barriers, and emergencies, which often impede timely access to essential medical supplies. Drones, or unmanned aerial vehicles (UAVs), have emerged as a promising solution to these issues, offering rapid and precise transportation of medications, vaccines, blood samples, and life-saving equipment to remote and underserved areas [1-3]. The significance of this technology is underscored by its potential to bridge healthcare disparities, improve emergency response, and ultimately save lives [2,4].

Recent advancements in drone technology have facilitated their incorporation into various healthcare applications, ranging from the delivery of medical supplies to emergency response and public health surveillance [4,5]. The use of artificial intelligence (AI) and intelligent pathway planning has further optimized drone operations, enabling efficient scheduling, obstacle avoidance, and real-time monitoring [6,7]. These technological enhancements have been

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validated through numerous case studies and experiments, demonstrating the efficacy of drones in reducing transportation time and costs while improving accessibility to healthcare services in underserved regions [1,3,7].

The COVID-19 pandemic has accelerated the adoption of drone technology in healthcare, highlighting its role in contactless delivery and minimizing human interaction to curb disease transmission [2,8]. Drones have been employed in various scenarios, including the delivery of blood products, medications, and vaccines, as well as in search-and-rescue missions and disaster management [5,9,10]. The integration of drones into healthcare logistics has also been explored in military contexts, where they have proven beneficial in improving the survivability of deployed forces [5].

The rapid development of drone technology has enabled innovative solutions to overcome the limitations of traditional transportation methods. For instance, hybrid delivery models that combine drones with trucks or incorporate charging stations have been proposed to extend drones' operational range and payload capacity [7,11]. Additionally, the use of advanced materials and design improvements has enhanced the safety and reliability of drone payloads, ensuring the secure transportation of medical supplies [11,12].

Despite these advancements, several challenges remain, including regulatory hurdles, privacy concerns, and the need for extensive validation of cost-effective business models [1,4,13]. Addressing these challenges requires a collaborative effort between civilian and military medical forces, as well as the development of supportive regulatory frameworks [4,5]. Future research should focus on multi-criteria optimization of drone delivery networks, the integration of IoT and blockchain technologies for enhanced security, and the development of AI-driven control techniques to improve efficiency and reliability [7,14,15]. Figure 1 shows the concept map for medical drone delivery generated using Scopus AI.

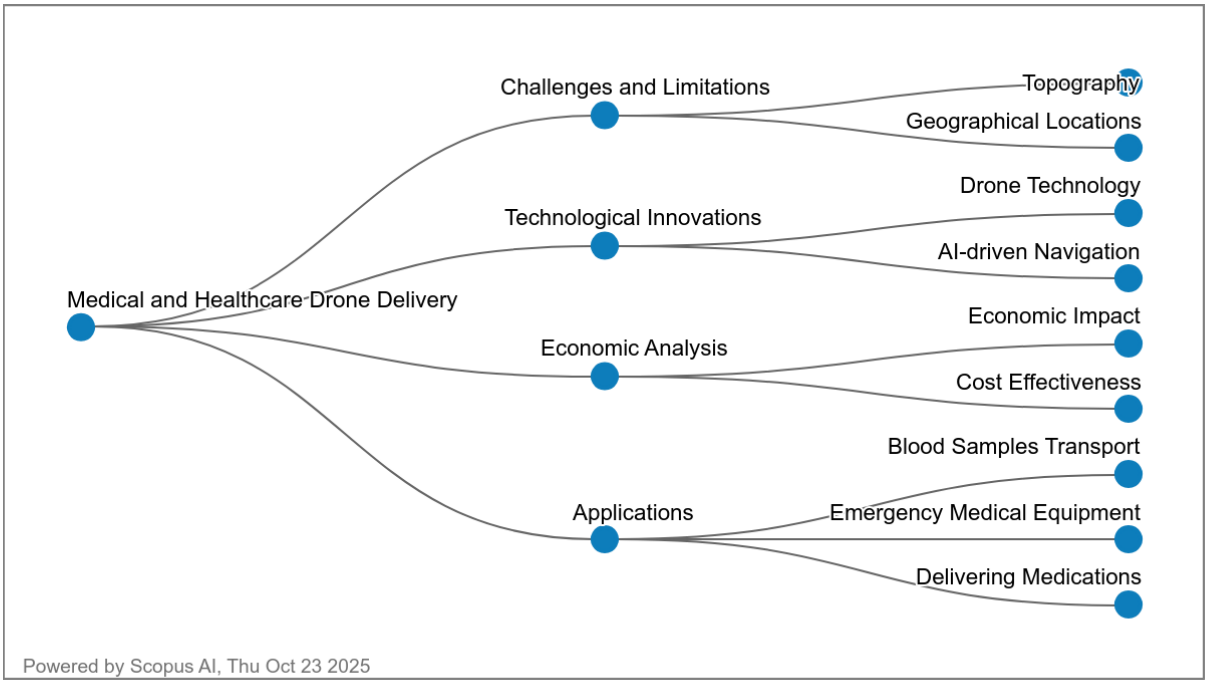

Figure 1: Medical drone delivery concept map.

The application of drone delivery in healthcare aligns with Sustainable Development Goal (SDG) 3, which focuses on ensuring healthy lives and promoting well-being across all population groups. This goal highlights the importance of equitable access to essential health services, medicines, and vaccines. Drone technology offers a practical approach to improving healthcare distribution, particularly in remote and underserved areas where conventional transport systems are limited. The capability to deliver medical supplies rapidly and reliably supports timely treatment and enhances service accessibility. In addition, drone-based logistics can assist public health programmes such as vaccination campaigns and disease monitoring activities. These functions contribute to strengthening healthcare systems and improving population health outcomes. The integration of drone technology into medical logistics, therefore, addresses existing distribution constraints while supporting more balanced service provision. Such developments demonstrate the relevance of innovative technological solutions in advancing healthcare accessibility and achieving the broader objectives associated with SDG 3.

In conclusion, integrating drone technology into healthcare logistics has immense potential to revolutionize medical supply delivery, particularly in remote and underserved areas. As technology advances and regulatory frameworks evolve, the widespread adoption of medical delivery drones is expected to significantly improve healthcare access and outcomes, offering a promising solution to contemporary healthcare challenges [1,2,4]. Bibliometric analysis is required to systematically map publication patterns and research trends, identify leading researchers in the field, evaluate influential studies, support keyword mapping, and support evidence-based development of medical drone delivery systems.

1.1 Research Question

- RQ1: How has the research on medical drone delivery evolved over time based on publication year?
- RQ2: Which articles in this research area have received the highest number of citations?
- RQ3: Which countries contribute the most publications to the field of medical drone delivery?
- RQ4: What are the most frequently used keywords in the literature related to this study?
- RQ5: How do countries collaborate in co-authorship within this research domain?

2. METHODOLOGY

Bibliometric analysis refers to a quantitative method used to evaluate scientific publications by examining patterns and relationships within academic literature [16-18]. This approach allows identification of general information such as influential authors, active publication years, and leading journals [19]. Beyond descriptive statistics, bibliometric techniques also include more complex procedures, for example, the assessment of co-citation linkages between documents. A comprehensive literature review requires a structured, iterative process that involves careful selection of search keywords, systematic retrieval of relevant records, and detailed screening of the collected materials. Such a methodical procedure is necessary to construct a representative dataset and to ensure the credibility of the results obtained [20].

In this study, emphasis was placed on high-impact journal articles because they are considered to make substantial contributions to the theoretical and conceptual development of the field. The Scopus database was chosen as the primary source of bibliographic data due to its wide coverage and recognized reliability [21-23]. To maintain data quality, only articles published in peer-reviewed academic journals were included, while other document categories, such as books, conference papers, and lecture notes, were excluded [24]. The final dataset was retrieved from Elsevier's Scopus database, covering publications from 2016 to October 2025.

2.1 Data Search Strategy

The identification of relevant publications followed a stepwise screening strategy to determine suitable search terms. The first stage was conducted in the Scopus database by applying a combined query that integrated keywords associated with unmanned aerial vehicles and the healthcare domain: ("drone" OR "drone delivery" OR "drone-delivery" OR "uav" OR "aerial drone") AND ("healthcare" OR "medical"). This initial search process generated 2,499 documents.

Subsequent filtering procedures were applied to improve the relevance and quality of the dataset. The selection was limited to original research articles written in English, while review papers and other document categories were excluded during this stage. After applying all inclusion and exclusion criteria, the dataset was reduced to 830 publications considered appropriate for bibliometric analysis. Therefore, the present analysis is based on all available Scopus-indexed journal articles related to medical drone delivery, with data collection completed in October 2025. The detailed inclusion and exclusion criteria applied in the data search strategy are presented in Table 1.

Table 1: Searching selection criterion.

Criterion	Inclusion	Exclusion	Result
Title-Abs-Key	("drone" OR "drone delivery" OR "drone-delivery" OR "UAV" OR "aerial drone") AND ("healthcare" OR "medical")	-	2,499
Language	English	Non-English	2,445
Timeline	2016 – 2025	< 2016	2,283
Literature type	Journal (Article)	Conference, Book, Review	857
Publication Stage	Final	In Press	830

Date of access: October 2025

2.2 Data Analysis

The bibliometric mapping process was carried out using VOSviewer version 1.6.19, specialized software developed by researchers at Leiden University for science mapping and network visualization [25,26]. This application is widely applied in bibliometric studies to transform raw bibliographic records into structured visual representations. It enables detailed examination of collaboration patterns among authors and countries, citation connections between publications, and co-occurrence relationships among keywords. Through its clustering function, related items are grouped into specific clusters, allowing clearer identification of thematic structures within a research domain. In addition, the software can generate density visualizations that illustrate the concentration and intensity of relationships in a given network. The system architecture of VOSviewer is designed to manage large-scale datasets efficiently without sacrificing analytical clarity.

One important capability of VOSviewer is the transformation of complex bibliographic information into spatial network maps that are easier be interpret. In these maps, the relative position and distance between nodes reflect the degree of similarity or relatedness among items. This visualization principle differs from the approach used in Multidimensional Scaling (MDS) [27]. While MDS often applies similarity indicators such as the cosine coefficient, the VOS approach generally relies on normalized co-occurrence measures. A frequently used metric in this context is the association strength (ASij), which is calculated from the standardized relationship between two items [28].

$$AS_{ij} = \frac{c_{ij}}{w_i w_j} \quad (1)$$

which is "proportional to the ratio between on the one hand the observed number of cooccurrences of i and j and on the other hand the expected number of co-occurrences of i and j under the assumption that co-occurrences of i and j are statistically independent" [28].

3. RESULTS AND DISCUSSION

3.1 Global Research Trend of Drone Technology in Healthcare Logistics

Based on the provided data, the field of medical drone delivery research has experienced substantial and consistent growth over the past decade. The number of publications has increased more than tenfold, rising from just 15 documents in 2016 to 152 in 2025 (projected or partial data) as presented in Figure 2. This represents a dramatic surge in scholarly interest, with the annual publication count growing from 2016 to 2025, except for a slight dip between 2022 and 2023. The most significant year-on-year growth appears to have occurred between 2019 and 2020, where publications jumped from 44 to 66, a 50% increase, signalling a potential acceleration in the field's development.

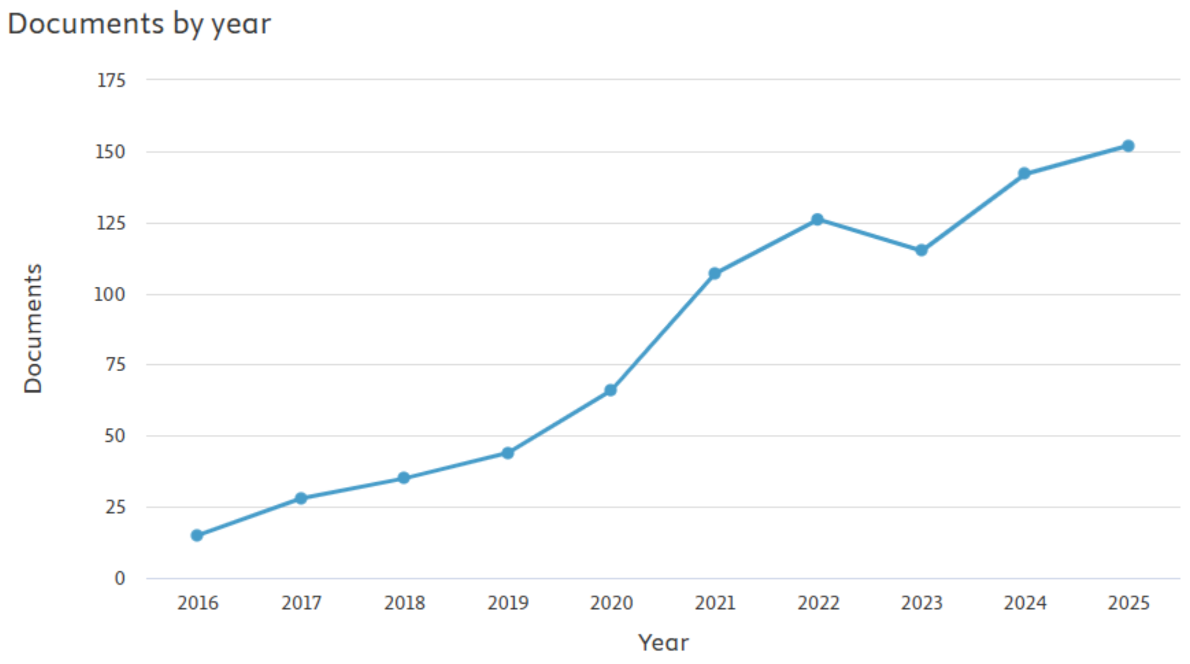

Figure 2: Research trend in medical drone delivery by year.

The distribution of publications by year shows a distinct, powerful upward trajectory. The most recent four-year period (2022-2025) accounts for a dominant 64.46% of all publications from the entire decade. This concentration indicates that research in this domain has not merely grown but has exploded in recent years, becoming a mainstream topic of investigation. In contrast, the first four years of the data set (2016-2019) account for only 14.7% of the total output, underscoring the field's nascent stage. The data for 2024 and 2025, showing the highest percentages (17.11% and 18.31%), suggest that this strong momentum is not only continuing but intensifying.

This trend is likely driven by converging technological and societal factors. Advances in drone technology, including improved battery life, payload capacity, and navigation systems, have made medical applications more feasible. Concurrently, the COVID-19 pandemic, which began in 2020, may have served as a catalyst, underscoring the urgent need for resilient, contactless logistics for medical supplies. The sustained high output in the most recent years suggests the field is moving from initial proof-of-concept studies toward more mature research focused on implementation, regulation, and the expansion of use cases, solidifying its position as a critical area of innovation in healthcare logistics.

The publication trend demonstrates exponential growth with high model fit, exceeding general UAV research expansion rates, suggesting a rapidly developing, high-impact niche within the broader UAV research landscape. The compound annual growth rate (CAGR) reflecting the total number of documents from 2016 (15 documents) to 2025 (152 documents) is 29.3% per year, indicating strong and sustained growth. The trend analysis shows that the exponential model provides a stronger fit ($R^2 \approx 0.95–0.97$) compared to the linear model ($R^2 \approx 0.88–0.91$). This indicates that publication growth follows an accelerating pattern rather than a constant increase, reflecting a rapid rise in research activity over time. In comparison with overall UAV research, which typically exhibits a growth rate of approximately 15–20% annually, the observed compound annual growth rate of about 29.3% in this field is considerably higher. This difference suggests that medical drone delivery is advancing faster than the broader UAV domain, highlighting its growing significance and strong potential for future research.

Table 2: Global research trend in medical drone delivery by years (2016-2025).

Year	Number of documents	Percentage (%)
2025	152	18.31
2024	142	17.11
2023	115	13.86
2022	126	15.18
2021	107	12.89
2020	66	7.95
2019	44	5.3
2018	35	4.22
2017	28	3.37
2016	15	1.81

3.2 Top 10 Most Cited Articles

Table 3 displays the ten most highly cited articles in the domain of drone technology applied to healthcare services.

Table 3: Top 10 most cited authors.

Title	Year	Source title	Cited by	Authors
A Comprehensive Review of the COVID-19 Pandemic and the Role of IoT, Drones, AI, Blockchain, and 5G in Managing its Impact	2020	IEEE Access	965	[29]
Wireless Network Intelligence at the Edge	2019	Proceedings of the IEEE	465	[30]
European Resuscitation Council Guidelines 2021: Basic Life Support	2021	Resuscitation	447	[31]
Security and Privacy in Smart Farming: Challenges and Opportunities	2020	IEEE Access	429	[32]
Lidar System Architectures and Circuits	2017	IEEE Communications Magazine	398	[33]
Machine Learning Adoption in Blockchain-Based Smart Applications: The Challenges and a Way Forward	2020	IEEE Access	321	[34]

Applications and Research avenues for drone-based models in logistics: A classification and review	2021	Expert Systems with Applications	297	[35]
A drone fleet model for last-mile distribution in disaster relief operations	2018	International Journal of Disaster Risk Reduction	269	[36]
Federated Deep Learning for Cyber Security in the Internet of Things: Concepts, Applications, and Experimental Analysis	2021	IEEE Access	256	[37]
MR fingerprinting Deep RecOnstruction NEtwork (DRONE)	2018	Magnetic Resonance in Medicine	246	[38]

The analysis of the most cited authors reveals that the foundational research in medical drone delivery is deeply interconnected with broader technological advancements, rather than existing as a standalone niche. The most cited publication, by Chamola et al. [29], situates drones within a suite of disruptive technologies, including IoT and AI, for pandemic management. This indicates that the field's initial high-impact recognition was largely driven by its perceived utility in addressing global crises, where drones were proposed as a critical component of integrated technological solutions. Similarly, highly cited works by Gupta et al. [32] on smart farming security and by Tanwar et al. [34] on machine learning and blockchain, although not exclusively focused on healthcare, provide crucial conceptual frameworks for security, data integrity, and automation that are directly transferable to medical logistics networks.

A closer examination of the sources and authorship highlights the interdisciplinary and applied nature of this research domain. The significant citation counts for papers published in high-impact engineering and technology journals, particularly IEEE Access and Proceedings of the IEEE, underscore the centrality of technological innovation in enabling medical drone applications. However, the presence of a clinical guideline paper by Olasveengen et al. [31] from Resuscitation among the most cited works is particularly telling. It signifies a critical bridge between technological potential and clinical necessity, suggesting that the delivery of life-saving interventions like defibrillators is a primary and compelling application that resonates strongly with both technical and medical research communities.

Finally, the list points to specific, high-value research avenues that have garnered significant academic attention. The papers by Moshref-Javadi & Winkenbach [35] and Rabta et al. [36] are seminal works that systematically formalized the application of drones within logistics and disaster relief models, providing the theoretical and operational backbone for last-mile medical supply distribution. It is also noteworthy that a paper like Cohen et al. [38], which uses "DRONE" as an acronym in a different context (Magnetic Resonance Imaging), appears on this list. This phenomenon likely introduces noise in bibliometric analyses and suggests that citation-based metrics, while informative, must be interpreted with caution and supplemented with content-specific validation to ensure the relevance of the captured literature.

3.3 Leading Countries Based on the Number of Publications

The global research landscape for medical drone delivery is characterized by clear geographical leadership, with the United States, India, and China emerging as the dominant contributors (Figure 3). The United States leads with 153 documents, closely followed by India (133) and China (130). This triad collectively accounts for a substantial proportion of the total scholarly output, indicating that the technological, regulatory, and operational development in this field is being primarily driven by these three nations. The prominence of the United States is consistent with its strong ecosystem of technological innovation and significant research funding. The high productivity from India and China underscores their rapid advancement in both drone technology and digital health infrastructure, positioning them as critical players in shaping the future of this domain.

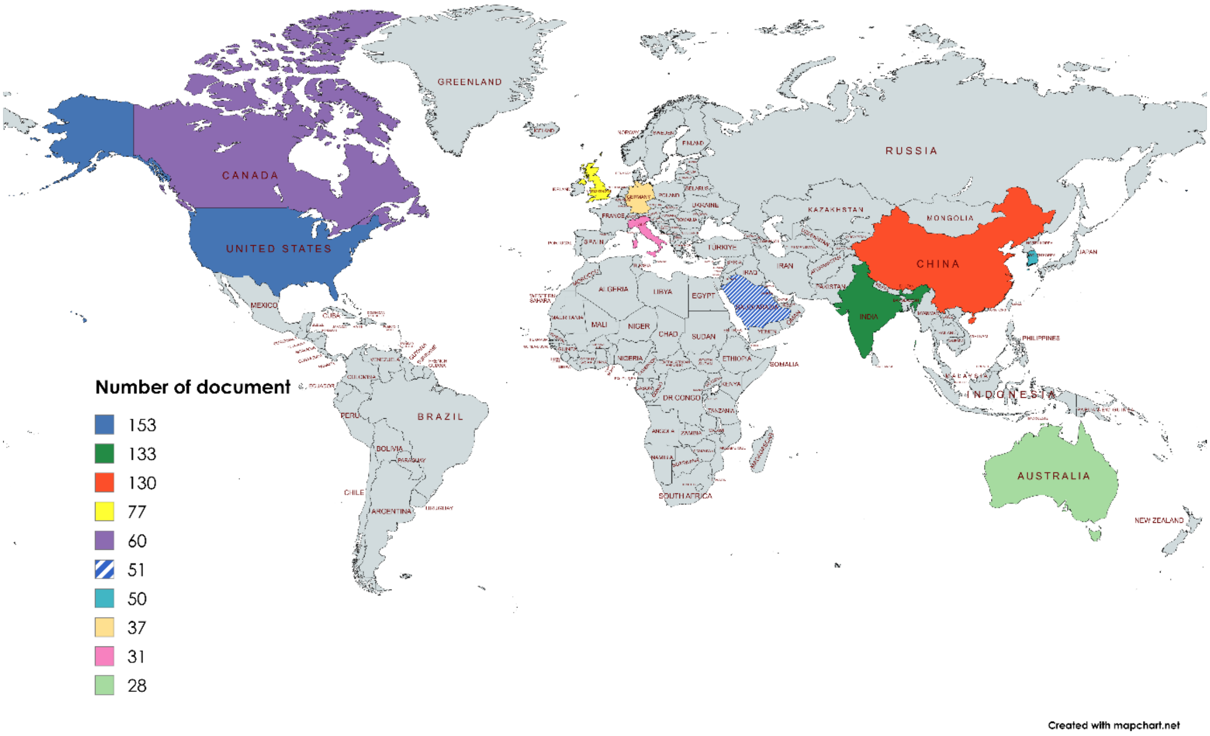

Figure 3: Most influential countries by documents.

Beyond the top three, the distribution of publications reveals a diverse yet concentrated international effort. Traditional research powers such as the United Kingdom (77), Canada (60), and Germany (37) maintain strong representation, reflecting sustained academic interest in applied engineering and public health logistics within high-income countries. Notably, the significant output from Saudi Arabia (51) and South Korea (50) highlights the strategic importance of this technology in specific regional contexts. For nations like Saudi Arabia, drones may offer solutions for logistics in challenging terrains, while South Korea's involvement aligns with its national focus on cutting-edge technology and efficient healthcare systems. This suggests that a combination of general research capacity and specific regional needs or strategic priorities influences the adoption of medical drone research.

The observed geographical distribution has important implications for the global transfer and implementation of medical drone technologies. The concentration of research in a few countries suggests that initial regulatory frameworks and technical standards are likely to be developed within these contexts. This could present both opportunities and challenges for global health equity. While knowledge transfer from these leading nations can accelerate adoption worldwide, there is a concurrent risk that solutions may be optimized for specific geographical or economic conditions, potentially limiting their applicability in low-resource settings that might benefit greatly. Therefore, future research must increasingly focus on fostering international collaboration to ensure that the development of medical drone delivery systems is inclusive and addresses a wide spectrum of global healthcare challenges.

3.4 Most Used Keywords

The keyword analysis reveals a field primarily defined by its core technological identity and a dominant application area, as illustrated in Figure 4. The most frequent and strongly linked terms are "unmanned aerial vehicles," "uav," "drone," and "drones", demonstrating a consolidated technological focus, though a lack of standardized terminology is apparent. The high total link strength of these terms indicates they serve as the central nodes connecting all other research themes. More significantly, the strong presence of "emergency medical services" and "out-of-hospital cardiac arrest," alongside the specific medical intervention "defibrillation," clearly identifies urgent pre-hospital care as the most prominent and well-established application driving scholarly inquiry. This suggests the field has successfully articulated a compelling use case in which drone technology offers a tangible solution to a critical, time-sensitive problem.

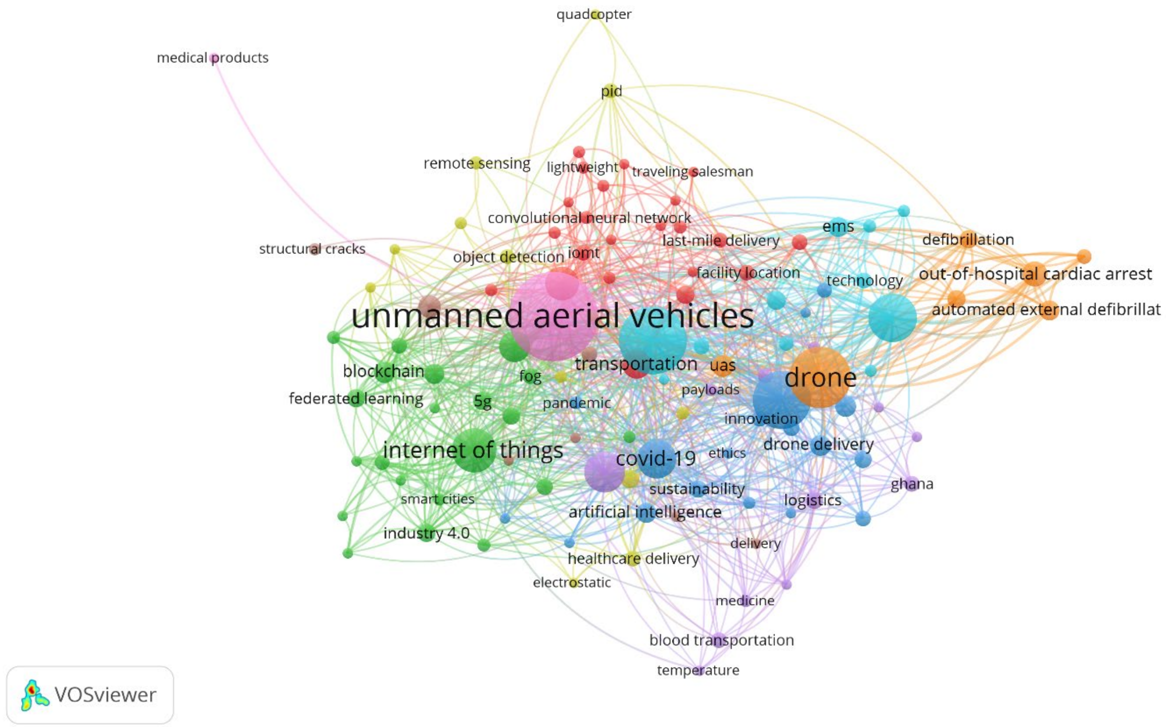

Figure 4: Network visualization map of keywords' co-occurrence.

A second major theme concerns the technological ecosystem required to operationalize medical drones. The significant occurrences and link strengths of "internet of things" (IoT) and "security" highlight that research extends beyond the vehicle itself to the digital infrastructure that supports it. This indicates an understanding that drones function not in isolation, but as connected data-gathering and transmitting nodes within a broader system. The integration of "deep learning" further points to research directions focused on enhancing autonomy, enabling complex tasks such as navigation in unstructured environments or predictive analytics for medical supply distribution. This cluster of keywords reflects the field's maturation, moving from conceptualizing the drone as a simple transport vehicle to viewing it as an intelligent component of a cyber-physical system.

The data also captures the field's responsiveness to global events, as evidenced by the strong association between "covid-19" and the core research topics. This connection underscores how the pandemic acted as a catalyst, highlighting the utility of drones for contactless logistics and medical supply chain resilience during a widespread health crisis. The presence of the broader term "healthcare" and the logistical focus of "transportation" indicates a gradual expansion of the research scope beyond emergency response. This points towards emerging investigations into the use of drones for routine medical deliveries, such as transporting blood products, vaccines, or laboratory samples, thereby integrating this technology into the wider healthcare and supply chain management landscape.

Table 4: Distribution of most keywords' co-occurrence.

Keyword	Occurrences	Total link strength
unmanned aerial vehicles	161	290
uav	102	201
drone	86	181
drones	78	173
emergency medical services	59	144
healthcare	44	118
internet of things	51	110
covid-19	41	108
iot	28	78
out-of-hospital cardiac arrest	20	64
transportation	25	61
deep learning	32	58
uas	16	51
defibrillation	12	47
security	14	43

3.5 Worldwide Co-authorship Networks

The analysis of international co-authorship reveals a distinct and influential network of collaborative hubs, rather than a simple correlation between high productivity and high collaboration. The United States and the United Kingdom emerge as the most central nodes, boasting the highest total link strength (113 and 101, respectively) alongside substantial document counts and citation figures. This indicates that their scholarly influence stems not only from high output but also from their role as primary collaborators in the global research landscape. Notably, Saudi Arabia presents a compelling case, as its total link strength (95) is disproportionately high relative to its document count (52), suggesting a research strategy that is intensely collaborative and internationally integrated from its outset.

The data further suggests the existence of distinct collaborative paradigms among major producing nations. While the United States and the United Kingdom maintain a strong balance between domestic output and international partnerships, other leading countries adopt different models. India and China, despite having document volumes comparable to the US, exhibit lower total link strength. This may indicate a greater focus on domestic research ecosystems or more regionally concentrated collaboration networks. Conversely, the significant international linkage of nations like Canada, Saudi Arabia, and Pakistan underscores how strategic partnerships can amplify the global reach and impact of research, potentially enabling these countries to punch above their weight in the international arena.

The composition of this collaborative network highlights the global and strategic nature of medical drone research. The presence of both traditional Western research powers (US, UK, Canada, Australia) and actively partnering nations from the Middle East and Asia (Saudi Arabia, Pakistan, South Korea) points to a field driven by a confluence of technological capability and specific regional logistical challenges. This pattern implies that knowledge is being co-created through partnerships that leverage diverse expertise, from advanced engineering in developed economies to implementation insights from regions where drone-based solutions may address critical infrastructure gaps. Consequently, the evolution of this field appears to be fundamentally shaped by a transnational network where collaboration is a key mechanism for integrating technological innovation with geographically specific healthcare delivery needs.

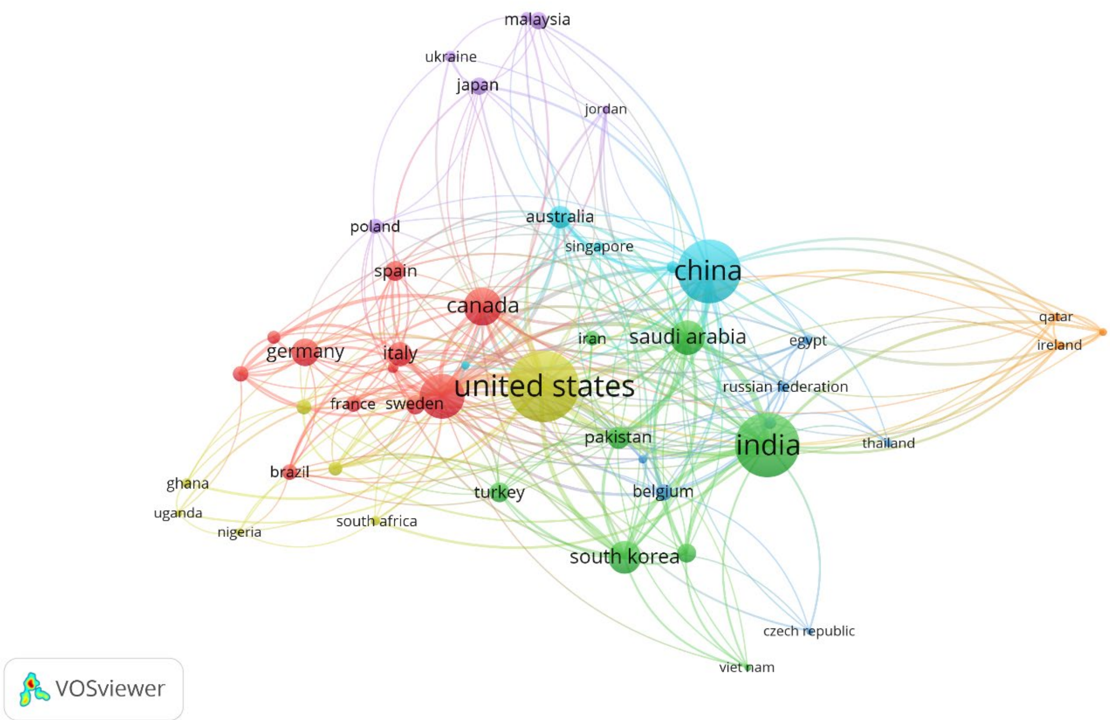

Figure 5: Network visualization map of co-authorship by countries' collaboration.

Table 5: Co-authorship by countries' collaboration.

Country	Documents	Citations	Total link strength
United States	155	5250	113
United Kingdom	77	2822	101
Saudi Arabia	52	1304	95
India	134	4441	92
China	131	3121	90
Canada	60	1544	70
South Korea	49	904	49
Pakistan	28	498	48
Australia	28	1451	39
Denmark	13	295	24
Taiwan	22	969	24
Portugal	9	253	23
Russian Federation	9	598	23
Switzerland	16	275	23
Belgium	17	914	22

4. CONCLUSION

This bibliometric analysis mapped the evolution and intellectual structure of medical drone delivery research from 2016 to 2025. The findings demonstrate a field experiencing explosive growth, with over 64% of its scientific literature published in the last four years. The research landscape is dominated by the United States, India, and China in terms of output, while the United Kingdom and Saudi Arabia emerge as central collaborative hubs. The conceptual core of the field is defined by its focus on unmanned aerial vehicles applied to emergency medical services, with strong connections to an enabling technological ecosystem that includes the Internet of Things, deep learning, and security.

The study provides a foundational map of the domain, highlighting its transition from theoretical logistics to a mature, convergent field addressing critical healthcare challenges like out-of-hospital cardiac arrest. The patterns of international collaboration and thematic clusters offer valuable insights for researchers and policymakers seeking to understand the field's dynamics. For practice, the convergence of engineering and clinical research underscores the real-world potential of drones to enhance medical supply chains and emergency response, particularly in remote or difficult-to-access regions.

While this analysis is limited by its reliance on a single database and the inherent constraints of bibliometric data, it establishes a robust baseline for future inquiry. Subsequent research should employ multi-database approaches and qualitative methods to deepen the understanding of implementation challenges and regulatory pathways. The significant momentum and clear trajectory identified confirm that medical drone delivery is a vital, rapidly advancing frontier in healthcare innovation, where technology and logistics converge to improve health outcomes.

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Declaration of Generative AI Use

During the preparation of this work, the authors used ChatGPT-5.2 to improve readability and language. After using this tool, the authors reviewed and edited the content as needed and take(s) full responsibility for the content of the publication.