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From Telephones to AI: A Seventy-Year Bibliometric Analysis of Emergency Call System Research

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Abstract. Emergency call systems (ECS) play a vital role in public safety, crisis management, and the organization of emergency response services. Over the last seven decades, these systems have evolved from simple telephone-based communication into complex, digital, and data-driven infrastructures integrating geolocation technologies, artificial intelligence, and multimodal communication. Despite their growing societal relevance, ECS research has not yet been examined through a comprehensive long-term scientific perspective. This study provides a bibliometric and science-mapping analysis of ECS literature published between 1952 and 2025, aiming to identify major research trends, collaboration patterns, and thematic shifts within the field, with particular attention to issues of accessibility and social inclusion. Publications indexed in Scopus and Web of Science were systematically analyzed using descriptive indicators and network-based techniques implemented through the Bibliometrix package in R (version 4.4.0) and VOSviewer. The results show a steady increase in ECS-related research, with accelerated growth after 2010 corresponding to advances in digitalization and intelligent communication technologies. Research output is concentrated primarily in high-income countries and focuses largely on operational efficiency, clinical response, and emergency communication infrastructures. Thematic evolution reveals a transition from early concerns with dispatch organization and response times toward more recent emphases on interoperability, system resilience, and intelligent emergency services. However, accessibility and inclusion, particularly concerning persons with disabilities—remain marginal within the literature, representing only a small fraction of published research. These findings indicate that while ECS research has developed into a multidisciplinary domain spanning public management, health systems, and information technologies, greater attention is required to address social equity, user diversity, and inclusive service design. The study contributes a structured overview of the field's evolution and highlights future research directions relevant to policymakers, emergency service managers, and scholars concerned with the social dimensions of emergency communication systems.

Keywords. Emergency call systems; Bibliometric analysis; Public safety; Resilience; Accessibility; Social inclusion; Public infrastructure

1. Introduction

Research on emergency call systems (ECS) has developed in parallel with advances in telecommunications, digital infrastructure, and public safety management. Early studies,

traceable in the Scopus database to the post-war period, focused primarily on emergency medical services (EMS), examining communication reliability, prehospital response times, and survival outcomes in critical situations (Carliner, 1952; Rottman & FitzGerald-Westby, 1981; Pepe et al., 1987; Becker et al., 1989). These early contributions, although largely clinical and technical in nature, established emergency communication as a fundamental public service and a core element of critical infrastructure.

From the 1990s onward, the expansion of digital technologies and the systematic coverage of scientific databases such as Scopus and the Web of Science enabled a broader and more structured development of ECS research. Studies increasingly addressed organisational coordination, emergency logistics, decision-making mechanisms, and system resilience, reflecting the growing complexity of emergency communication environments (Hou et al., 2021; Shen et al., 2022). Bibliometric and science-mapping approaches have been widely used in this context to analyse publication trends, thematic structures, and collaboration patterns, offering valuable insights into the evolution and diversification of emergency management research (Çetin et al., 2022; Passas, 2024).

Despite this expansion, existing literature reveals a persistent imbalance in research focus. Human-centred dimensions of emergency communication—such as accessibility for persons with disabilities, multilingual communication, and user experience—remain weakly represented in bibliometric analyses and keyword networks (Dodds & Palakshappa, 2021). Most studies continue to prioritise technological performance and clinical outcomes, while issues related to equitable access and user diversity receive comparatively limited attention.

Recent global challenges, including the COVID-19 pandemic and climate-related emergencies, have further influenced ECS research agendas. An increasing number of studies examine artificial intelligence, automated decision-support systems, and resilience frameworks aimed at improving system responsiveness and scalability (Wen et al., 2023). However, bibliometric evidence suggests that these innovations are frequently analysed from a technical or operational perspective, with limited consideration of inclusive design or accessibility requirements.

In response to these gaps, recent research on Romania's 112 emergency system illustrates how accessibility can be addressed as a performance dimension of emergency communication services. Bokor et al. (2025) highlight the role of location technologies in improving access to emergency services while aligning technical innovation with regulatory and social inclusion objectives. These findings underscore the need for a more systematic assessment of how accessibility and human factors are reflected within ECS research over time.

Against this background, the present study provides a longitudinal bibliometric analysis of ECS research indexed in Scopus (1952–2025) and the Web of Science (1991–2025). By combining descriptive indicators with science-mapping techniques, the study examines publication trends, thematic evolution, and geographic distribution of ECS research, with particular attention to the representation of accessibility and inclusion. In doing so, it offers a structured overview of the field's development and identifies persistent research gaps relevant to policymakers, emergency service managers, and scholars concerned with the future design of inclusive emergency communication systems.

2. Literature Review

Research on emergency call systems (ECS) has evolved in parallel with developments in telecommunications, digital infrastructure, and public safety management. Early studies, traceable in the Scopus database to the post-war period, focused primarily on emergency

medical services (EMS), examining communication reliability, prehospital response times, and survival outcomes in critical situations (Carliner, 1952; Rottman & FitzGerald-Westby, 1981; Pepe et al., 1987; Becker et al., 1989). Although predominantly clinical and technical in orientation, this early body of work established emergency communication as a fundamental public service and a key component of critical infrastructure.

From the 1990s onward, the expansion of digital technologies and the systematic indexing of scientific publications in databases such as Scopus and the Web of Science enabled a broader development of ECS research. Studies increasingly addressed organisational coordination, emergency logistics, decision-making processes, and system resilience, reflecting the growing complexity of emergency communication environments (Hou et al., 2021; Shen et al., 2022). In this context, bibliometric and science-mapping methods have been widely applied to analyse publication trends, thematic structures, and collaboration patterns within emergency management research (Çetin et al., 2022; Passas, 2024).

Despite this expansion, literature reveals a persistent imbalance in research focus. Human-centred aspects of emergency communications such as accessibility for people with disabilities, multilingual communication, and user experience—remain weakly represented in bibliometric analyses and keyword networks (Dodds & Palakshappa, 2021). Most studies continue to prioritise technological performance and clinical outcomes, while issues related to equitable access and inclusiveness receive comparatively limited attention.

Recent global challenges, including the COVID-19 pandemic and climate-related emergencies, have further influenced ECS research agendas. An increasing number of studies examine artificial intelligence, automated decision-support systems, and resilience frameworks aimed at improving system responsiveness and scalability (Wen et al., 2023). However, bibliometric evidence suggests that these developments are still largely analysed from technical or operational perspectives, with limited emphasis on accessibility or inclusive system design.

More recent research focusing on national emergency systems illustrates how accessibility can be addressed as a performance dimension of ECS. Studies based on Romania's 112 emergency system demonstrate how technological solutions, such as location-based services, can contribute to improving access to emergency communication while aligning with regulatory and social inclusion objectives (Bokor et al., 2025). These findings highlight the need for a systematic assessment of how accessibility and human factors are reflected within ECS research over time.

By integrating the extended historical coverage of Scopus with the post-1991 coverage of the Web of Science, the present study provides a dual-database perspective on the evolution of ECS research. It identifies thematic trends, collaboration patterns, and persistent research gaps, particularly regarding accessibility and inclusion. This gap is especially relevant considering Directive (EU) 2019/882, which requires the accessibility of emergency communication services across the European Union. The present bibliometric review contributes to this discussion by offering a structured overview of ECS research development and by highlighting areas requiring greater attention in future studies.

3. Methodology

3.1 Research Design and Data Sources

This study employs a bibliometric analysis to examine the evolution of Emergency Call System (ECS) research over time. The analysis is based on publications indexed in the Scopus and Web of Science databases, which were selected due to their broad coverage of peer-reviewed scientific literature. To capture both historical development and recent research

trends, two time periods were considered: 1952–1990 (Scopus) and 1991–2025 (Scopus and Web of Science).

Only journal articles and conference proceedings were included in the analysis. Publications were limited to English and major European languages to ensure data consistency and comparability.

3.2 Data Collection and Processing

Bibliographic records were retrieved in 2025 using identical search queries in both databases. The exported records included information on authors, affiliations, publication year, keywords, abstracts, and cited references. Duplicate records were removed, and basic standardisation procedures were applied to author names and keywords to improve consistency across datasets.

The analysis focused on descriptive indicators such as annual publication output, geographic distribution of research, core publication sources, and keyword occurrence patterns.

3.3 Analytical Tools

The bibliometric analysis was conducted using established software tools commonly applied in science-mapping studies. Descriptive statistics and keyword analyses were generated using Bibliometrix (Biblioshiny) and R, while network visualisations for co-authorship and keyword co-occurrence were produced using VOSviewer. These tools enabled a structured examination of publication trends and thematic structures within ECS research.

3.4 Methodological Limitations

This study relies on metadata provided by Scopus and Web of Science, and differences in database coverage and indexing practices may influence the visibility of certain publications. In addition, bibliometric analyses reflect patterns in published research rather than the full scope of operational practices in emergency services. Despite these limitations, the combined use of two major databases provides a robust overview of long-term research trends in ECS scholarship.

4. Results

4.1 Evolution of Scientific Production in Emergency Call System Research

The longitudinal analysis reveals a clear temporal evolution in Emergency Call System (ECS) research output. As shown in *Figure 1*, the period between 1952 and 1990 is characterised by low and irregular publication activity, with fewer than five publications per year on average. This early phase reflects the nascent stage of ECS research, which was largely embedded within clinical and emergency medical service contexts.

From 1991 onward, publication activity increases steadily, followed by a pronounced acceleration after 2010. This growth coincides with the digitalisation of emergency communication, the expansion of mobile telephony, and increased policy attention to emergency service performance. The sustained rise in annual output indicates the consolidation of ECS research as a distinct and multidisciplinary field.

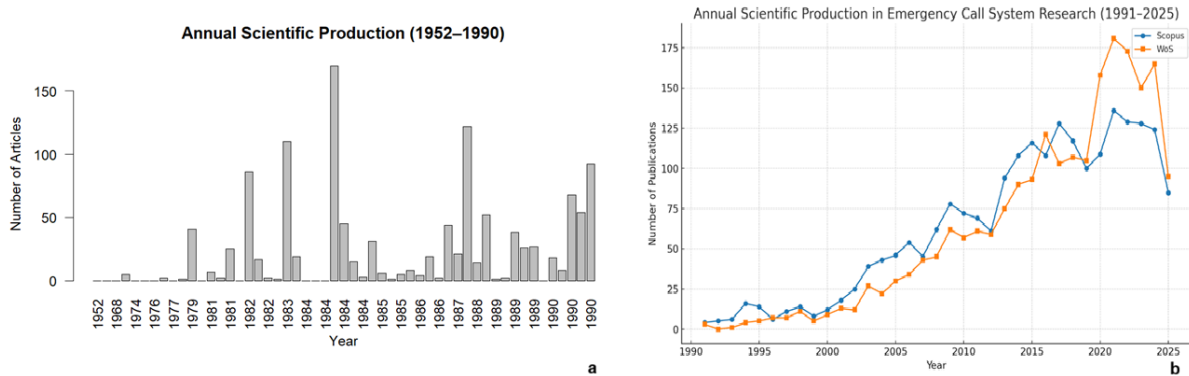


Figure 1. Annual scientific production in Emergency Call System research (1952–2025). Panel (a) illustrates the early, irregular development of Emergency Call System (ECS) research between 1952 and 1990, characterised by low publication volumes and episodic peaks. Panel (b) shows the sustained growth and consolidation of the field from 1991 to 2025, based on Scopus and Web of Science records, with a marked acceleration after 2010 reflecting increased technological integration and policy attention.

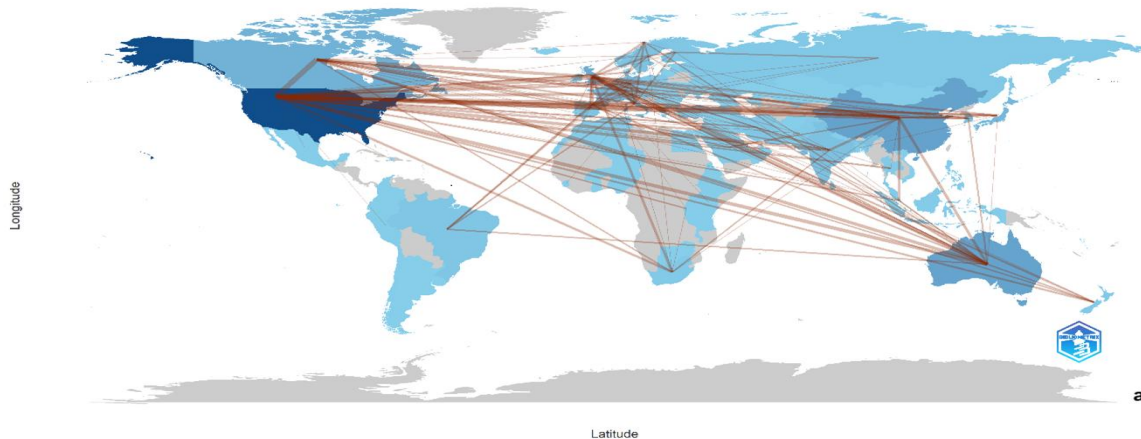
Source: Authors' elaboration based on bibliographic records extracted from Scopus and Web of Science.

4.2 Geographic Distribution of ECS Research Output

Figure 2 illustrates the global geographic distribution of ECS research between 1952 and 2025. Research output is highly concentrated in a limited number of high-income countries, particularly in North America and Western and Northern Europe. In contrast, low- and middle-income regions exhibit markedly lower levels of scientific production.

This uneven geographic distribution highlights structural imbalances in global ECS research and suggests that knowledge generation is closely linked to economic capacity, technological infrastructure, and institutional research funding. The limited contribution from under-resourced regions raises important questions regarding the transferability of research findings and the inclusiveness of emergency communication systems across different socio-economic contexts.

Country Collaboration Map



Country Collaboration Map



Figure 2. Geographic distribution of Emergency Call System (ECS) research (1952–2025). *Figure 2 illustrates the global geographic distribution of Emergency Call System (ECS) research output, revealing a strong concentration of publications in a limited number of high-income countries and a comparatively low level of research activity in low- and middle-income regions. This uneven distribution highlights structural imbalances in global emergency communication research and raises questions regarding equity, transferability of knowledge, and accessibility of emergency services across different jurisdictions.*

Source: Authors' elaboration based on bibliographic records extracted from Scopus and Web of Science.

4.3 Thematic Structure and Keyword Co-Occurrence

The thematic structure of ECS research is examined through keyword co-occurrence analysis. As shown in *Figure 3*, the keyword network is dominated by *clinical*, *emergency medical services*, and *cardiac arrest*-related terms, forming the most central and strongly connected clusters.

Keywords associated with *emergency communication*, *call handling*, *accessibility*, and *inclusive system design* appear weakly connected and positioned at the periphery of the network. This pattern indicates a thematic imbalance, where medical performance outcomes receive

communication are largely absent. This concentration reflects the historical framing of ECS primarily as a medical and prehospital care issue, rather than as a component of broader public safety infrastructure or public service management.

Table 1. Top publication sources for emergency call system research (1952–1990) based on Scopus data.

Rank	Source Title	Publications
1	Annals of Emergency Medicine	11
2	American Journal of Emergency Medicine	4
3	BMJ	3
4	Pediatrics	2
5	Archives of Internal Medicine	1

Source: Authors' elaboration based on bibliographic records extracted from Scopus and Web of Science.

4.5 Conceptual Synthesis of Research Priorities and Gaps

Building on the bibliometric findings, *Figure 4* provides a conceptual synthesis linking dominant ECS research themes to their implications for emergency services management. The synthesis highlights a strong alignment between research focus and system design priorities centred on *clinical performance*, *response time*, and *technological optimisation*.

At the same time, the synthesis reveals persistent gaps in areas related to *accessibility*, *inclusive communication*, *call-taker-centred management*, and *organisational governance*. These gaps help explain why technological progress in ECS has not been matched by equivalent advances in equitable access and user diversity.

The conceptual framework underscores the need to rebalance ECS research priorities by integrating accessibility and inclusion as core performance dimensions alongside efficiency and clinical outcomes.

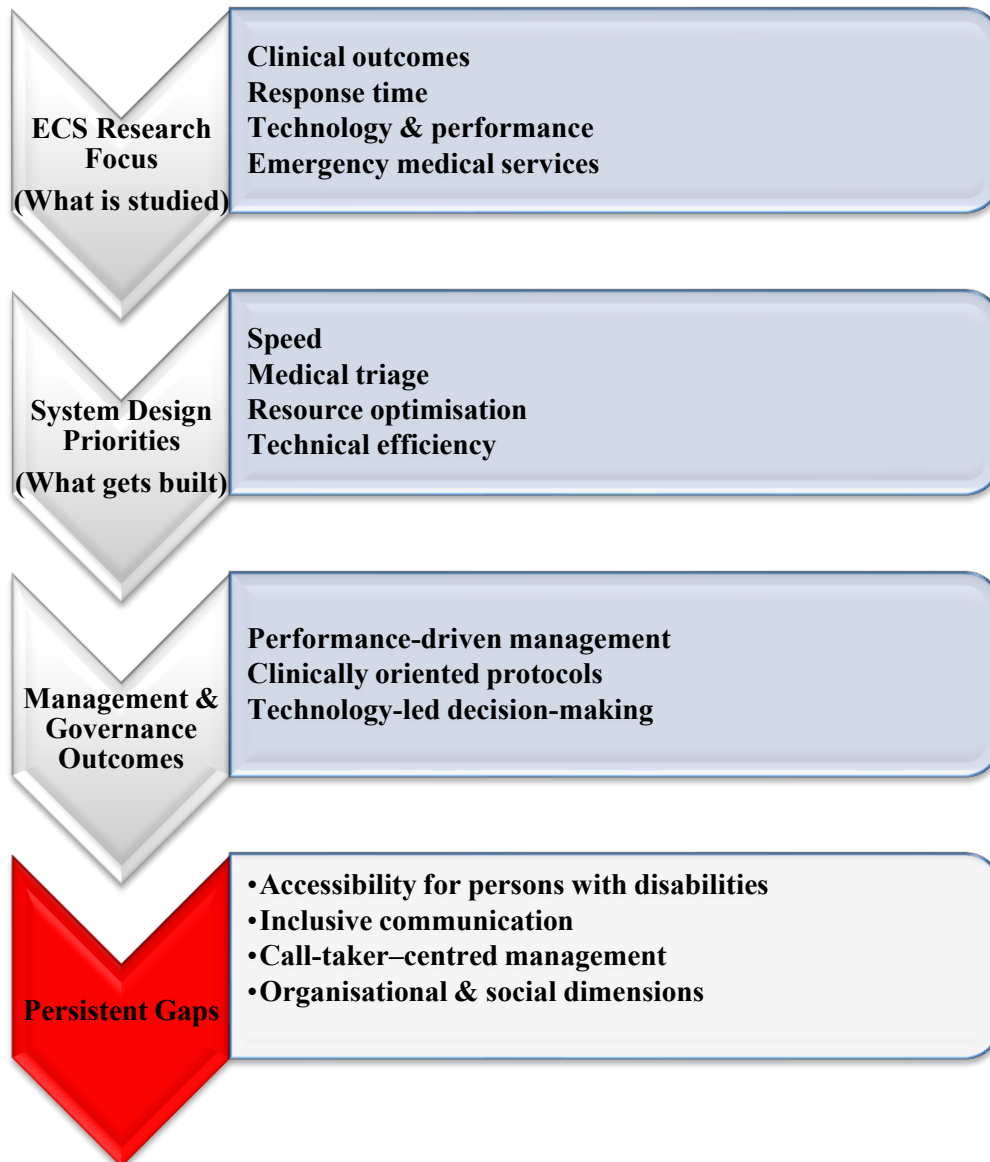


Figure 4. Conceptual synthesis of Emergency Call System research priorities and their implications for emergency services management.

Figure 4 synthesises the bibliometric findings by linking dominant research themes in Emergency Call System (ECS) studies to prevailing management and governance priorities in emergency services. While research has strongly emphasised clinical performance, response time, and technological optimisation, themes related to accessibility, inclusive communication, and organisational management remain marginal. This imbalance helps explain persistent gaps between technological advancement and equitable access to emergency services.

Source: Authors' elaboration.

5. Discussion

Emergency call system (ECS) research has reached a stage of relative maturity, as demonstrated by bibliometric trends identified through Scopus (Elsevier 2025) and Web of

Science (Clarivate 2025), which reveal continuous growth and gradual thematic diversification over the past seven decades. The field has evolved from early medical and technical orientation toward more complex integrations of artificial intelligence, caller-location technologies, mobile communication, and next-generation emergency systems. This transformation reflects how digitalisation and innovation have become central to the management of public safety infrastructure.

However, the geographic and economic distribution of ECS research remains uneven. Most publications originate in high-income regions, resulting in a persistent innovation gap between well-resourced emergency systems operating under fiscal or technological constraints. Consequently, operational models developed in advanced economies may lack transferability to low- and middle-income contexts. This imbalance highlights the need for context-sensitive research that accounts for differences in governance capacity, financing structures, and communication infrastructure.

The comparison between Scopus and Web of Science further demonstrates that database selection influences bibliometric outcomes. Scopus offers broader temporal and geographic coverage, whereas Web of Science captures more cohesive citation networks and established collaboration patterns. Employing a dual database strategy therefore strengthens analytical validity and provides a more comprehensive view of disciplinary evolution, particularly in an interdisciplinary field such as ECS that intersects technology, management, and social policy.

Despite sustained technological progress, accessibility for persons with disabilities remains critically underrepresented in ECS scholarship. This finding contrasts sharply with the legal and normative obligations established under the UN Convention on the Rights of Persons with Disabilities and the European Accessibility Act (European Parliament and Council 2019). As argued by Dodds and Palakshappa (2021), neglecting accessibility in emergency communication generates both tangible costs, such as system retrofitting, and intangible costs, including delayed interventions, unequal service outcomes, and increased long-term social expenditure.

To address this gap, future research should reposition accessibility not merely as a compliance requirement, but as an economic and ethical imperative that enhances system efficiency, resilience, and public trust. Broader research participation from under-represented regions, greater inclusion of grey literature, and the use of mixed-method approaches could support the development of more inclusive and adaptable emergency communication models. ECS research increasingly occupies a pivotal position at the intersection of technology, safety, and welfare economics, and its progress will be measured by how effectively inclusivity is integrated into efficiency-driven innovation.

6. Conclusion

This study provided a bibliometric overview of Emergency Call System (ECS) research indexed in Scopus (1952–2025) and the Web of Science (1991–2025), examining long-term publication trends, thematic development, and research distribution. The results show that ECS research has expanded steadily over the past decades, evolving from an early clinical and technically oriented focus toward a more diversified field that includes organisational, technological, and system-level perspectives.

Despite this growth, the analysis highlights clear imbalances in the literature. Research output remains concentrated in a limited number of countries, and thematic attention continues to prioritise medical performance, response processes, and technological solutions. In contrast,

topics related to accessibility, inclusion, and user diversity are consistently underrepresented within the ECS research landscape.

These findings suggest that, while emergency communication systems have benefited from significant technological advancement, corresponding academic attention to equitable access and inclusive system design has lagged behind. From a research perspective, this gap indicates the need for broader thematic coverage that reflects the diversity of emergency service users and communication needs.

By offering a structured bibliometric synthesis of ECS scholarship over more than seven decades, this study contributes to a clearer understanding of how the field has developed and where future research efforts may be directed. Increased attention to accessibility and inclusion within ECS research could support the development of emergency communication systems that are not only technologically advanced, but also more responsive to the needs of all users.

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