

GLOBAL RESEARCH TRENDS (2011-2025) IN CALCIUM CHANNEL BLOCKER POISONING: A SCOPUS-BASED BIBLIOMETRIC ANALYSIS

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ABSTRACT

Calcium channel blockers (CCBs) account for a substantial proportion of poisoning-related morbidity and mortality worldwide. This bibliometric study aimed to evaluate global publication patterns, research productivity, and thematic development in Scopus-indexed literature on CCBs poisoning from 2011 to 2025. A title-restricted Scopus search identified publications related to CCBs poisoning between 2011 and 2025. Records were screened according to PRISMA 2020 guidelines, refined using Microsoft Excel, and analyzed using the Bibliometrix package (R version 4.5.2). Descriptive bibliometric indicators and Multiple Correspondence Analysis (MCA) were applied to assess research performance and conceptual structure. A total of 349 publications were included, comprising 322 original articles (92.3%) and 27 reviews (7.7%), representing contributions from 47 countries. The United States led global output (25.8%), followed by China (7.7%) and India (7.4%). Pearson correlation analysis demonstrated no statistically significant linear trend in annual publication output ($r = -0.048$, $p = 0.866$), indicating a stable but fluctuating research trajectory over time. Keyword co-occurrence mapping identified dominant thematic clusters centered on acute overdose management, cardiovascular instability, intensive care interventions, and advanced supportive therapies, particularly high-dose insulin euglycemia therapy. To conclude, the contemporary Scopus-indexed literature on CCBs poisoning reflects a geographically concentrated yet thematically evolving research landscape. Scientific production remains dominated by a limited number of high-income countries, with restricted international collaboration and underrepresentation of low- and middle-income regions. Strengthening multicenter research initiatives and toxicovigilance systems is essential to improve global inclusivity and evidence-based management of CCBs toxicity.

Keywords: Bibliometric, Scopus, Calcium channel blockers, Drug overdose, Poisoning, Toxicity

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INTRODUCTION

Calcium channel blockers (CCBs) are a commonly prescribed group of cardiovascular agents used for hypertension, angina, selected arrhythmias, and vasospastic conditions [1]. These drugs act primarily by blocking L-type voltage-gated calcium channels in vascular smooth muscle, cardiac myocytes, and conduction tissue, thereby diminishing myocardial contractility and slowing atrioventricular conduction, lowering heart rate, and producing peripheral vasodilation [2].

Introduced into U. S. clinical practice in the 1970s as components of antihypertensive regimens, they rapidly became established for treating vasospastic and stable angina [3]. However, particularly in overdose settings, calcium channel blocker (CCB) can produce life-threatening toxicity [4].

According to published clinical reports; overdose of immediate-release formulations may rapidly progress to hypotension and bradyarrhythmia, while extended-release formulations may produce delayed onset of dysrhythmias, shock and cardiac collapse [5].

The seriousness of CCB toxicity is highlighted by accumulating evidence: a systematic review of treatment strategies for CCB overdose reported the use of high-dose insulin euglycemia therapy (HIET), intravenous calcium, lipid emulsion therapy, and extracorporeal life support in case reports and small series, yet mortality remained appreciable [6]. Further, a recent review of combined β -blocker and CCB toxicity emphasizes the high morbidity and mortality associated with CCB overdoses and the need for early recognition and specialized management. These data underscore the seriousness of the clinical problem, the complexity of its management, and the need for improved evidence-based approaches [7].

Mechanistically, CCB overdose perturbs intracellular calcium handling in cardiac and vascular smooth muscle cells, reducing contractile force, impairing conduction, and causing vasodilator shock [8]. The negative inotropic and chronotropic effects lower cardiac output and perfusion pressure, while vasodilation decreases systemic vascular resistance—together precipitating cardiogenic and distributive shock. Additionally, inhibited calcium influx into pancreatic β -cells can impair insulin secretion and provoke hyperglycemia, worsening metabolic instability and outcomes [9].

Epidemiologically, CCB poisoning continues to represent a major toxicology concern. Calcium channel blockers overdoses rank among the most potentially lethal prescription-drug ingestions in adults, with multiple case series and poison-center databases reporting high frequencies of severe medical events and deaths [8, 10, 11]. The American Heart Association (AHA) update in 2023 emphasized early HIET in life-threatening β -blocker and CCB poisoning [9].

Bibliometric analysis, which uses quantitative methods to map the structure, dynamics and knowledge flows of scientific literature, is a useful tool to assess publication volume, citation impact, geographic and institutional productivity, research themes and collaboration networks over time [12].

A pivotal bibliometric study by Zyoud analyzed Scopus-indexed CCB poisoning research from 1968 to 2012 [10] retrieving 713 publications across 53 countries, finding the United States contributed about 30% of outputs, followed by the United Kingdom (7.4%), Japan (6.0%), and Germany (5.6%), and noting that around 75% of World Bank-listed countries produced no publications in this topic revealing pronounced geographic gaps [13]. That work also reported limited international collaboration and called for further epidemiologic, mechanistic, and clinical investigations in underrepresented regions.

The period 2011–2025 was intentionally selected to extend and update the previous bibliometric analysis by Zyoud *et al.*, which covered 1968–2012[10]. This non-overlapping timeframe allows for evaluation of contemporary research developments, evolving management strategies, and emerging therapeutic approaches in CCB poisoning.

This study aims to (a) quantify the volume and temporal trends of Scopus-indexed CCB poisoning literature from 2011 to 2025; (b) identify productive contributors across countries, institutions, journals, and authors; (c) evaluate citation activity and influential scholarship; and (d) generate and interpret an author-keyword co-occurrence network to reveal dominant research themes and their conceptual structure. By providing an updated overview of the scientific landscape in CCB poisoning, this study supports clinicians, toxicologists, pharmacologists, and policy-makers in identifying emerging priorities and research gaps. Furthermore, it contributes to strengthening international collaboration and guiding strategic research investment in this field.

METHODS

Data source and search strategy

This bibliometric investigation used the Scopus database because of its broad biomedical journal coverage and compatibility with structured data export for quantitative analysis. Publications addressing calcium channel blocker (CCB) toxicity and related effects from 2011 to 2025 were evaluated. An initial title-only query produced 1,610 records. Applying the study-period filter (2011–2025) reduced this to 439 records. These 439 entries underwent manual title-and-abstract screening to remove items not focused on toxicity or toxicity outcomes. After screening, 349 pertinent papers were retained for analysis and data extraction. The study selection process was conducted in accordance with the PRISMA 2020 guidelines, and the corresponding flow diagram illustrating identification, screening, eligibility, and final inclusion is presented in Supplementary fig. 1.

A title-based Boolean search was designed to combine terms for CCB drug classes and individual agents with terms related to poisoning, overdose, toxicity, medication errors and adverse outcomes. The full search strategy was defined as (TITLE ("calcium channel blocker*" OR "calcium channel antagonist*" OR "calcium channel blocking "OR "calcium antagonist*" OR "calcium blocker*" OR "Ca channel blocker*" OR "Ca antagonist*" OR "voltage-gated calcium channel*" OR "L-type calcium channel*" OR CCB OR CCBs OR dihydropyridine* OR "non-dihydropyridine*" OR amlodipine OR levamlodipine OR azelnidipine OR barnidipine OR benidipine OR benidipine OR bencyclane OR bepridil OR cilnidipine OR clevidipine OR cinnarizine OR felodipine OR fendiline OR flunarizine OR gallopamil OR isradipine OR lacidipine OR lercanidipine OR lidoflazine OR manidipine OR mibefradil OR nicardipine OR nifedipine OR nimodipine OR nisoldipine OR nitrendipine OR prenylamine OR verapamil OR diltiazem) AND TITLE (poison* OR "self-poison*" OR intoxicant * OR "drug overdose" OR overdose OR "over dosage" OR "over-dosage" OR "acute ingestion" OR ingest* OR exposure OR "toxic exposure" OR "drug overuse" OR "drug misuse" OR "medication error*" OR "prescribing error*" OR "administration error*" OR "dispensing error*" OR "adverse effect*" OR "adverse event*" OR "adverse reaction*" OR "adverse drug reaction*" OR ADR OR "side effect*" OR "side-effect*" OR toxic* OR toxicity OR toxicological* OR "toxicity profile" OR complication* OR "drug induced" OR iatrogenic OR "fatal case*" OR mortality OR death OR "case report" OR "case series" OR "poison center" OR "toxicology center") AND PUBYEAR>2010 AND PUBYEAR<2026 AND (LIMIT-TO (DOCTYPE, "ar") OR LIMIT-TO (DOCTYPE, "re")) AND (LIMIT-TO (SUBJAREA, "MEDI") OR LIMIT-TO (SUBJAREA, "PHAR")) AND (LIMIT-TO (LANGUAGE, "English"))).

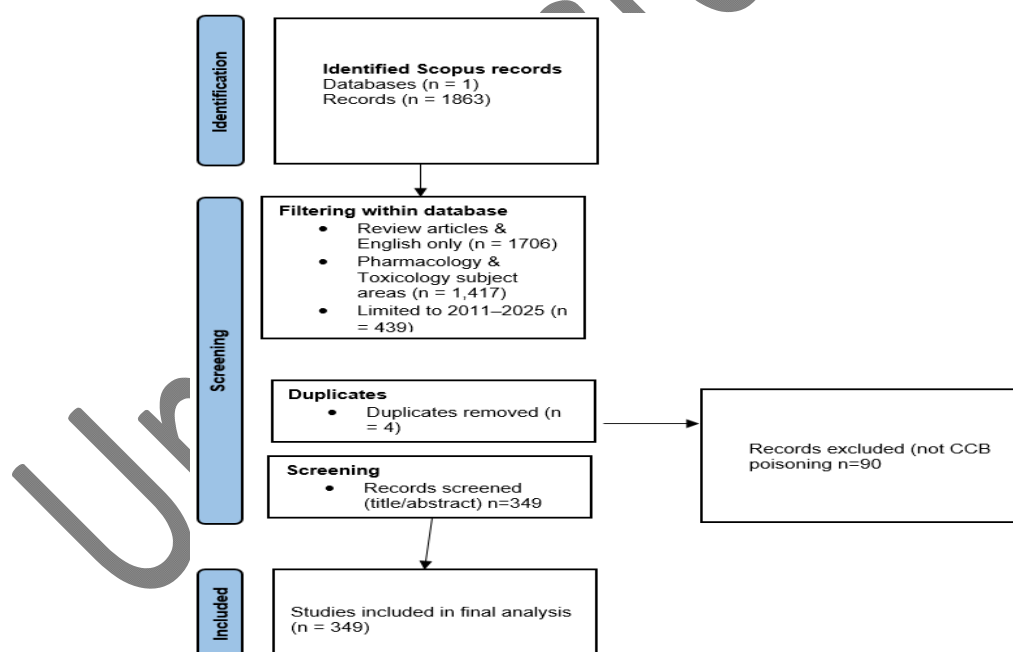


Fig. 1: PRISMA 2020 flow diagram of the study selection process

Data cleaning and standardization

To ensure coherent clustering during literature mapping, keywords for CCB drug classes, author names, and institutional designations were standardized manually in Microsoft Excel 365. Variant spellings and alternative representations of the same institutions or keywords were consolidated to prevent node fragmentation in subsequent co-authorship and citation analyses.

Duplicate entries were detected using the automated duplicate-checking function in the Bibliometrix package and were independently verified through manual cross-checking in Microsoft Excel. This dual-validation approach ensured dataset integrity and eliminated redundant records prior to final analysis.

Institutional names were manually harmonized to consolidate variations and affiliated designations (e. g., university systems, medical centers, and campus-specific names) under unified institutional entities. This standardization prevented artificial fragmentation of institutional productivity and ensured accurate attribution in ranking analyses.

After manual curation, the cleaned file was analyzed in R Studio using Bibliometrix as the analytic tool for deduplication, verification of unique records, and maintenance of a stable bibliographic structure suitable for science mapping and conceptual analysis. The finalized dataset for bibliometric interpretation consisted of 349 unique publications focused on calcium antagonist poisoning and adverse-effect outcomes.

Research performance indicators

Publishing activity was described using quantitative indicators such as total document count, document types and proportions, annual publication rates, corresponding-author country contributions, institutional productivity, journal distribution, and synchronization of author and keyword appearances (extracted from the "Spatial Distribution" field). Outputs were ranked using Standard Competition Ranking (SCRa), retaining only the top 10 values for each output set. In the event of tied values, ranking gaps were preserved to avoid artificial competition.

Network and conceptual mapping

Co-word networks of dominant author keywords were generated using Bibliometrix conceptual-structure mapping (Multiple Correspondence Analysis—MCA). Multiple Correspondence Analysis (MCA) was selected due to its suitability for high-dimensional categorical bibliographic data and its ability to reveal latent conceptual structures through dimensional reduction. Unlike distance-based visualization tools, MCA enables thematic clustering based on multidimensional proximity, providing a more interpretable conceptual framework for keyword relationships. Only thematic content directly relevant to CCB poisoning, toxicity, and clinical outcomes was retained during interpretation of network clusters, while keywords that deviated from poisoning-related concepts were excluded manually.

Statistical analysis

The results were reported descriptively using absolute counts and percentages. No population-weighted, economic or demographic national parameters were employed to remain focused on quantitative bibliometric mapping. A Pearson correlation test was applied to examine the linear relationship between publication year and annual research output. All analyses were conducted in order to explore trends in publication activity and citation patterns, and to ensure clarity in identifying influential positions within the field. All bibliometric and statistical analyses were performed using RStudio (R version 4.5.2) with the Bibliometrix package (version 5.2.1). Conceptual mapping and visualization were conducted using Biblioshiny, the web-based interface of Bibliometrix.

RESULTS

A total of 349 Scopus-indexed documents on calcium channel blocker (CCB) poisoning published between 2011 and 2025 are described in this bibliometric study. The dataset was dominated by original research articles (322, 92.3%), while review papers formed a smaller proportion (27, 7.7%). Collectively, the 349 included publications accumulated approximately 4,160 citations, corresponding to an average of 11.92 citations per document, reflecting moderate citation impact within the field of clinical toxicology. The relative share of global CCB poisoning research output during the period 2011–2025 showed temporal variation, with publications accounting for 13.3% between 2011 and 2013, 22.6% between 2014 and 2016, 21% between 2017 and 2019, 16.4% between 2020 and 2022, and 23.8% between 2023 and 2025 (fig. 2). A Pearson correlation analysis showed no significant association between publication year and the annual number of articles ($r = -0.048$, $p = 0.866$). This indicates that the yearly output did not follow a consistent upward or downward trend during the study period.

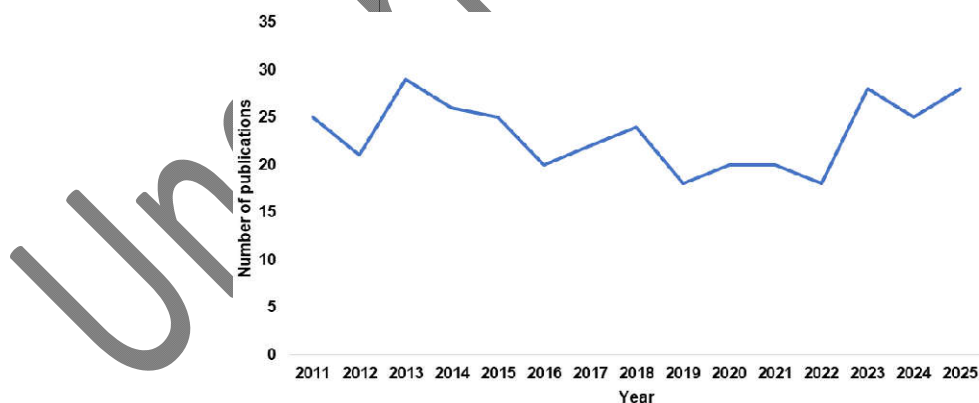


Fig. 2: Annual scientific production of calcium channel blocker (CCB) poisoning publications (2011–2025)

The annual distribution of documents followed a non-linear production pattern, with the most significant early publication peak occurring in 2013. The retrieved CCB poisoning records were published by contributing authors affiliated with 47 countries, reflecting the global engagement indexed in the Scopus dataset. Table 1 summarizes the top 10 countries according to corresponding-author publication output and cross-national collaboration indicators. Article production was led by the United States (90 documents, 25.8% of the total corpus), followed by China (27, 7.7%), India (26, 7.4%), Turkey (19, 5.4%), and Japan (14, 4.0%). Collectively, the top five countries contributed 176 publications, accounting for 50.4% of all retrieved documents, indicating that half of the Scopus-indexed scholarship on CCB poisoning during this period was produced by a small cluster of highly productive nations, while the remaining 41 countries shared a considerably smaller proportion of the overall research.

Table 1: Research productivity and collaboration indicators in CCB poisoning literature indexed in scopus (2011-2025)

Ranking (SCR)	Country	Articles (n, %)	Single country publications-SCP (n, %)	Multiple country publications-MCP (n, %)	MCP %
1 st	USA	90 (25.8)	86 (24.6)	4 (1.1)	4.4
2 nd	China	27 (7.7)	24 (6.9)	3 (0.8)	11.1
3 rd	India	26 (7.4)	24 (6.9)	2 (0.5)	7.7
4 th	Turkey	19 (5.4)	19 (5.4)	0 (0.0)	0.0
5 th	Japan	14 (4.0)	14 (4.0)	0 (0.0)	0.0
6 th	France	11 (3.2)	10 (2.8)	1 (0.3)	9.1
7 th	South Korea	10 (2.9)	10 (2.9)	0 (0.0)	0.0
8 th	UK	10 (2.9)	8 (2.3)	2 (0.5)	20.0
9 th	Canada	9 (2.6)	8 (2.3)	1 (0.3)	11.1
10 th	Italy	8 (2.3)	6 (1.7)	2 (0.5)	25.0

CCB: Calcium channel blocker; SCR: Standard competition ranking; MCP: Multiple country publications; MCP% represents the percentage of internationally collaborative publications relative to a country's total output.

The annual publication growth rate was 0.81%, and the mean age of the analyzed documents was 7.03 years, reflecting sustained but gradual research activity in calcium channel blocker (CCB) poisoning literature. Table 2 indicates that the most frequent journals were Clinical Toxicology (15 papers; 4.3%; IF = 3.122; SJR = 1.129), American Journal of Emergency Medicine (10 papers; 2.9%; IF = 1.152; SJR = 0.592), and Indian Journal of Critical Care Medicine (9 papers; 2.6%; IF = 1.50; SJR = 0.505), indicating that toxicology and emergency/critical care journals represent the primary publication venues. British Medical Journal Case Reports accounted for the most frequent case-report publications (7 papers; 2.0%; IF = 0.5; SJR = 0.219). Several journals were ranked fifth, each publishing 6 papers (1.7%), including high-impact emergency medicine outlets (British Medical Journal) and cardiovascular-focused journals (Europace). Consistent pharmacology-toxicology contributions were observed in specialized clinical pharmacology journals (5 papers; 1.4% each), highlighting the multidisciplinary nature of the field. Overall, the distribution of publications across journals reflects a concentration in toxicology, emergency medicine, and critical care disciplines, with additional contributions from pharmacology and cardiovascular research domains.

Table 2: Top 10 Scopus-indexed sources contributing to calcium channel blocker (CCB) poisoning literature (2011-2025): journal frequency and subject-domain profile

SCR	Journal	Frequency-articles (n, %)	IF ^b	SJR ^{b,c}	Subject domain/Categories
1 st	Clinical Toxicology	15 (4.3)	3.122	1.129	Toxicology
2 nd	American Journal of Emergency Medicine	10 (2.9)	1.152	0.592	Emergency Medicine
3 rd	Indian Journal of Critical Care Medicine	9 (2.6)	1.50	0.505	Critical Care/Toxicology
4 th	British Medical Journal Case Reports	7 (2.0)	0.5	0.219	Medicine, General and Internal
5 th	Annals of Emergency Medicine	6 (1.7)	5.0	0.836	Emergency Medicine
5 th	Cardiovascular Toxicology	6 (1.7)	3.7	0.834	Toxicology/Cardiovascular
5 th	Journal of Medical Case Reports	6 (1.7)	0.8	0.390	Medicine, General and Internal
5 th	Journal of Medical Toxicology	6 (1.7)	NA	0.421	Toxicology
9 th	Basic and Clinical Pharmacology and Toxicology	5 (1.4)	NA	0.656	Pharmacology: Toxicology
9 th	British Journal of Clinical Pharmacology	5 (1.4)	3.0	1.178	Pharmacology

CCB: calcium channel blocker; SCR: standard competition ranking; SJR: SCImago journal rank; NA: not available; IF: impact factor; ISI: Institute for Scientific Information; JCR: journal citation reports. Equal-ranked journals share the same SCR number, followed by a subsequent ranking gap in the sequence. ^b Impact Factor (IF) and SCImago Journal Rank (SJR) values correspond to the latest available year (2024–2025). NA indicates that the journal is not indexed in Journal Citation Reports (JCR) or Scopus at the time of data extraction. ^c SCImago Journal Rank (SJR) values were retrieved from the SCImago Journal and Country Rank portal (2024).

Table 3 presents the most cited publications addressing CCB poisoning between 2011 and 2025. The highest total citation count was recorded by Engebretsen *et al.* (2011) with 177 citations (Normalized TC = 7.30), followed by St-Onge *et al.* (2014) with 132 citations (Normalized TC = 5.26), and St-Onge *et al.* (2017) with 120 citations (Normalized TC = 7.59). These highly cited studies primarily focused on treatment strategies and consensus recommendations for management of severe CCB toxicity.

Table 3: Top cited publications within the CCB poisoning focused subset (2011-2025)

SCR	Authors and year	Study title	Source/Journal	Total citations	Normalized TC
1 st	Engebretsen <i>et al.</i> (2011)	High-dose insulin therapy in beta-blocker and calcium channel-blocker poisoning	Clinical Toxicology	177	7.30
2 nd	St-Onge <i>et al.</i> (2014)	Treatment for calcium channel blocker poisoning: A systematic review	Clinical Toxicology	132	5.26
3 rd	St-Onge <i>et al.</i> (2017)	Experts Consensus Recommendations for the Management of Calcium Channel Blocker Poisoning in Adults	Critical Care Medicine	120	7.59

4 th	Graudins <i>et al.</i> (2016)	Calcium channel antagonist and beta-blocker overdose: antidotes and adjunct therapies	British Journal of Clinical Pharmacology	117	5.33
5 th	French <i>et al.</i> (2011)	Serum verapamil concentrations before and after Intralipid® therapy during treatment of an overdose	Clinical Toxicology	65	2.68
6 th	Levine <i>et al.</i> (2013)	Critical Care Management of Verapamil and Diltiazem Overdose with a Focus on Vasopressors: A 25-Year Experience at a Single Center	Annals of Emergency Medicine	57	3.52
7 th	Jang <i>et al.</i> (2011)	Methylene Blue in the Treatment of Refractory Shock from an Amlodipine Overdose	Annals of Emergency Medicine	57	2.35
8 th	Monteiro <i>et al.</i> (2011)	Diltiazem poisoning treated with hyperinsulinemia euglycemia therapy and intravenous lipid emulsion	European Journal of Emergency Medicine	51	2.10
9 th	Liang CW <i>et al.</i> (2011)	Toxicological study of mebudipine and dibudipine poisoning: a case-based analysis	Journal of Medical Case Reports	46	1.9
10 th	Doepker B <i>et al.</i> (2014)	Deliberate hypotensive anesthesia with the rapid reversal of amlodipine toxicity	Journal of Emergency Medicine	42	1.67

CCB: Calcium channel blocker; SCR: Standardized Ranking; TC: Total Citations; N: Number of Publications; TC/N: Total Citations per Publication; TC/N (years): Total Citations per Publication (years); TC/N (years) (all wings): Total Citations per Publication (years) (all wings); TC/N (years) (explicitly addressing calcium channel blocker poisoning): Total Citations per Publication (years) (explicitly addressing calcium channel blocker poisoning); TC/N (years) (explicitly addressing calcium channel blocker poisoning) (all wings): Total Citations per Publication (years) (explicitly addressing calcium channel blocker poisoning) (all wings).

Table 4 highlights the most productive institutions in CCB poisoning research. Gyeongsang National University (Republic of Korea) and the University of Florida System (USA) ranked first, each contributing 14 publications (4.0%). The University of California System (USA) followed with 10 publications (2.9%), while Harvard Medical School (USA) contributed 7 publications (2.0%).

Table 4: Top 10 most highly productive institutions on CCB poisoning

SCR	Institution	Country	No. of documents (%)
1 st	Gyeongsang National University	South Korea	14 (4.0%)
1 st	University of Florida System	USA	14 (4.0%)
2 nd	University of California System	USA	10 (2.9%)
3 rd	Harvard Medical School	USA	7 (2.0%)
4 th	VA Medical Center	USA	6 (1.7%)
5 th	John Radcliffe Hospital	UK	5 (1.4%)
5 th	Massachusetts General Hospital	USA	5 (1.4%)
5 th	Astellas Pharma	Japan	5 (1.4%)
10 th	Hôpital Lapeyronie	France	4 (1.1%)
10 th	Universität zu Lübeck	Germany	4 (1.1%)

Percentages were calculated based on the total number of included publications (n = 349).

Fig. 3 presents the conceptual structure map derived from Multiple Correspondence Analysis (MCA) of high-frequency author keywords. Two dominant thematic clusters were identified. The first cluster was primarily centered on acute clinical manifestations and emergency management, including terms such as hypotension, bradycardia, cardiogenic shock, intensive care, and resuscitation strategies. This cluster reflects the strong clinical orientation of CCB poisoning research toward hemodynamic instability and critical care interventions.

The second cluster emphasized therapeutic and antidotal strategies, including high-dose insulin euglycemia therapy, intravenous lipid emulsion, vasopressor support, and advanced supportive treatments. This pattern indicates that contemporary research prioritizes optimization of management protocols and evaluation of treatment efficacy in severe overdose cases.

The proximity of these clusters suggests that clinical severity and therapeutic innovation are tightly interconnected themes within the current scientific landscape of CCB toxicity research.

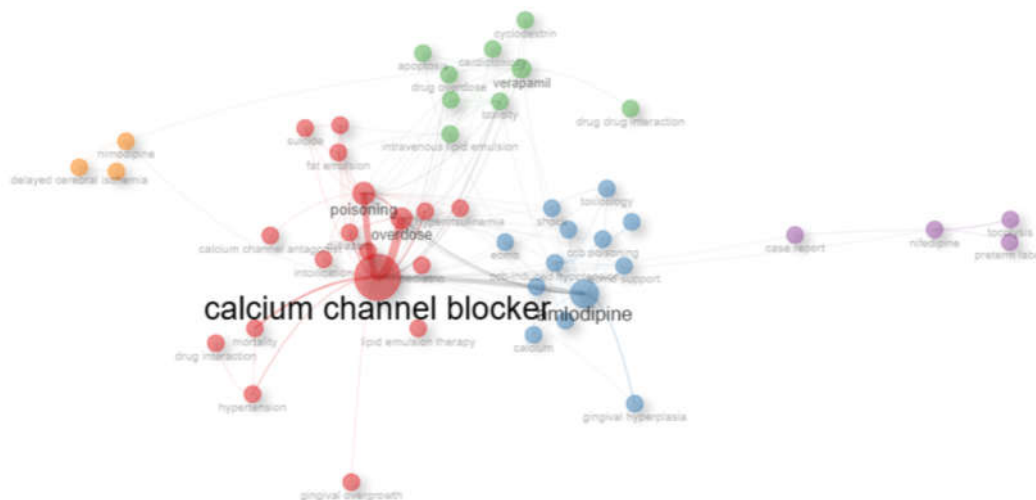


Fig. 3: Conceptual structure map of author keywords in calcium channel blocker (CCB) poisoning literature generated using multiple correspondence analysis (MCA) through the Bibliometrix package (R version 4.5.2) and visualized via Biblioshiny. Colors represent distinct thematic clusters identified through dimensional reduction of high-frequency keywords

DISCUSSION

This study used bibliometric analysis to examine research trends in Scopus-indexed literature on calcium channel blocker poisoning from 2011 to 2025. The chosen timeframe allowed for tracking the most recent phase of CCB poisoning studies, with a particular focus on clinically relevant toxicity cases—such as hypotension, bradycardia, and refractory shock—that typically require intensive care unit (ICU)-level care. Starting the dataset in 2011 ensured a smooth transition from previous bibliometric assessments that largely concluded in 2012, minimizing redundancy and reflecting the period when Scopus coverage of CCB overdose and poisoning reports became more clinically structured and methodologically mature.

In this context, the study aimed to assess the global research landscape, identify countries and institutions with significant publication contributions, and explore the academic influence of key authors shaping evidence on calcium channel blocker (CCB) overdose cases, strategies for stabilizing acute poisonings, management approaches, and clinical outcomes. This analysis also supported a qualitative understanding of how CCB poisoning research has evolved in recent years within the broader framework of clinical toxicology.

This review was limited to 349 documents extracted from Scopus, with article titles containing terms related to CCB poisoning, and therefore cannot be generalized to the literature on CCBs included in other databases (e. g. Google Scholar). Scopus offers broader journal coverage and enhanced citation-tracking capabilities compared with PubMed and Web of Science [14-17].

Although annual publication output fluctuated across the study period, Pearson correlation analysis did not demonstrate a statistically significant linear upward trend over time ($r = -0.048$, $p = 0.866$). This trend aligns with the overall growth pattern in globally documented toxicology research, where total scientific output has witnessed a significant acceleration in recent decades [18-20]. In our database, publication output fluctuated over time without a statistically significant linear trend, but the range of journals and study types has also broadened—from classical toxicology case reports to more diverse outlets in clinical toxicology and emergency medicine (such as critical care, emergency medicine, and pharmacology), as evidenced by the prominence of journals like *Clinical Toxicology*, the *American Journal of Emergency Medicine*, and the *Indian Journal of Critical Care Medicine* among the top sources.

This expansion likely reflects a combination of factors, including the increased clinical use of CCBs worldwide, growing awareness of the risks of overdoses, and the development of pharmacovigilance—particularly with the wider availability of newer CCB formulations (including extended-release and modified-release types). Extended-release formulations can lead to delayed and prolonged absorption, resulting in atypical toxicity profiles and delayed intoxication, which may spark renewed research interest in overdose management [21-23]. Simultaneously, there has been a notable shift in research focus toward therapeutic and antitoxic strategies rather than purely descriptive toxicology. Among the most cited and influential studies in our review were those addressing treatment modalities such as high-dose insulin (HDI), intravenous lipid emulsion (ILE), and other advanced supportive measures [23-25]. In this study, the average citation rate was 11.92 citations per article, indicating an increase in citations compared to previous reports on the same topic, but still average compared to other well-planned toxicology topics. For comparison, a similar bibliometric study on paracetamol toxicity research reported an average of 12.3 citations per article, reflecting a slightly higher citation accumulation than this study [26]. Another bibliometric analysis of the literature on hookah smoking showed an average citation rate of 13 citations per document, indicating an increase in citations compared to research on CCB poisoning [27]. These findings suggest that citation density in toxicology research may be influenced not only by clinical severity but also by public health visibility and integration into national surveillance systems. This difference in citation impact may be attributed to variations in epidemiological burden and public health prioritization. Paracetamol toxicity remains one of the most common causes of acute drug poisoning worldwide and is frequently incorporated into national surveillance systems and clinical guidelines, thereby attracting broader research attention and higher citation density. In contrast, CCB poisoning, although clinically severe, occurs less frequently and is typically managed within specialized toxicology and critical care settings.

Other findings resemble those found in other bibliographic studies in toxicology and poisonings, such as the dominant position of the United States about scientific production, having the largest number of papers produced, supporting the highest number of Single-Country Publications (SCP), and showing the highest percentage of International Collaborations among countries that publish research papers [26-28]. The concentration of research output in high-income countries likely reflects disparities in toxicology research infrastructure, funding availability, and the presence of well-established poison control centers and surveillance systems. High-income nations typically maintain structured toxicovigilance programs and comprehensive reporting mechanisms that facilitate data collection and publication productivity. On the other hand, some general views of national productivity also support the hypothesis that research activity in CCB poisoning remains limited or nonexistent in most countries, with a clear bias

toward high-income countries and few emerging outputs from developing regions—an observation similarly found in bibliometric studies on poisoning, which highlight gaps in toxicology capacity [29]. These regions continue to report a lack of structured postgraduate toxicology programs, limited institutional funding, and underdeveloped emergency poisoning registries, all of which may contribute to the low research presence [30-32].

This study has several limitations. First, restricting the search strategy to title-only terms may have excluded studies in which calcium channel blocker poisoning was discussed primarily within abstracts or keywords. Although this approach increases specificity, it may have led to underestimation of the total research volume in the field. Furthermore, limiting inclusion to the MEDLINE and PHAR subject areas may have excluded interdisciplinary publications indexed under other categories, thereby introducing subject-classification bias. In addition, restricting the analysis to English-language publications may result in linguistic bias and underrepresentation of research from non-English-speaking regions, as previous bibliometric research has demonstrated [33]. Reliance on a single database (Scopus) may also limit retrieval of relevant papers indexed exclusively in other authoritative databases such as Web of Science or PubMed, potentially affecting overall literature coverage [34]. Additionally, restricting inclusion to original research articles and review papers may have excluded letters, editorials, conference abstracts, and brief reports that occasionally contain early clinical observations or emerging therapeutic insights related to CCB toxicity. Finally, bibliometric analysis evaluates publication and citation trends rather than direct clinical outcomes; therefore, findings should be interpreted within the context of research productivity and conceptual development rather than therapeutic effectiveness.

CONCLUSION

This updated bibliometric analysis provides the first post-2012 global mapping of calcium channel blocker (CCB) poisoning research trends. The findings demonstrate a gradual increase in scientific output, with research predominantly concentrated in high-income countries and specialized toxicology and critical care settings. Despite improvements in citation impact and thematic development, international collaboration remains limited, and geographic disparities in research productivity persist.

Future research should prioritize the establishment of multicenter clinical registries and structured toxicovigilance systems, particularly in low-and middle-income countries, to enhance epidemiological surveillance and data reliability. Further investigations into long-term clinical outcomes of CCB poisoning, optimization of high-dose insulin protocols, and the development of novel antidotal and targeted therapeutic strategies are warranted. Strengthening global research collaboration and supporting capacity-building initiatives in underrepresented regions may contribute to a more balanced scientific landscape and improved evidence-based management of CCB toxicity.

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ETHICAL APPROVAL

Ethical approval was not required for this study because it utilized publicly available bibliographic data and did not involve human participants, personal data, or confidential information.

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USE OF ARTIFICIAL INTELLIGENCE

No artificial intelligence (AI) tools were used in data extraction, analysis, or result generation. AI-based tools were used only for language editing and did not influence scientific content or analysis.

AUTHORS CONTRIBUTIONS

All authors have contributed equally

CONFLICT OF INTERESTS

The authors declare that they have no conflicts of interest.

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