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Research trends and hotspots in HIV pre-exposure prophylaxis: a bibliometric analysis and visual mapping

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Abstract

HIV remains a major global public health challenge, and pre-exposure prophylaxis (PrEP) has established itself as a pivotal evidence-based strategy for HIV prevention. While research on PrEP has expanded rapidly, a comprehensive synthesis of the existing literature is lacking. This review systematically analyzes trends, collaborative networks, and research hotspots in PrEP through a bibliometric approach to consolidate current knowledge and inform future directions. A total of 5,273 PrEP-related publications (1992-2025) from the Web of Science Core Collection were included, showing a 15.99% annual growth rate. The field is dominated by contributions from the United States (2,969 publications), with the University of Washington as a core institutional contributor and the Journal of Acquired Immune Deficiency Syndromes as the most prolific journal; Baeten JM emerges as a key collaborative figure. Key research hotspots include PrEP implementation, HIV prevention in men who have sex with men, adherence issues, and the development of long-acting agents (e.g., cabotegravir). Emerging trends highlight growing focus on long-acting formulations, awareness promotion, and multi-sectoral collaboration. This synthesis underscores the expanding significance of PrEP research, offering critical insights for clinicians, researchers, and policy-makers. Future efforts should prioritize advancing long-acting PrEP applications, addressing barriers such as limited awareness and economic burdens, and strengthening cross-sector collaboration to maximize PrEP's role in global HIV control.

Keywords: *Bibliometric analysis. Pre-exposure prophylaxis. Research trends. Hotspots.*

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Introduction

Globally, HIV infection remains a major public health issue that poses a serious threat to human health[1]. Despite significant advancements in antiretroviral therapy (ART), however, HIV prevention remains a critical pillar in controlling the AIDS epidemic[2]. Pre-exposure prophylaxis (PrEP) has garnered considerable attention in recent years as an evidence-based, effective prevention strategy for HIV infection[3]. PrEP is a biomedical prevention strategy whereby high-risk individuals administer ART to mitigate their risk of HIV infection[4]. Numerous clinical trials have demonstrated that PrEP effectively reduces the risk of HIV infection among high-risk populations[5-7]. When taken consistently, PrEP has been shown to achieve high prophylactic efficacy, with effectiveness rates reaching up to 99% in clinical trials among men who have sex with men (MSM)[8,9].

PrEP has achieved growing international recognition since its initial introduction. In 2012, the World Health Organization (WHO) first released its formal recommendation on PrEP[10]. By 2014, the WHO had recommended offering PrEP to MSM[11]. Subsequently, in 2015, WHO expanded its recommendation to encompass all individuals at substantial risk of HIV infection[12]. The global adoption of PrEP has continued to rise, evidenced by the increasing number of countries implementing PrEP programs and the growing user base. According to the WHO data, by 2020, 129 countries and territories had integrated WHO's PrEP recommendations into their national guidelines on a cumulative basis[13]. Notably, the global PrEP user count experienced substantial growth in 2020, exceeding 900,000 individuals[14].

The exponential growth of HIV PrEP literature poses significant challenges for systematic review. Bibliometrics analyzes macro-level research characteristics throug quantitative methods – such as citation network analysis, keyword co-occurrence trends, or author-institution influence. Visual mapping (e.g., clustering maps, temporal evolution diagrams) reveals discipline trends, aiming to decipher research dynamics, collaboration patterns, and knowledge structure evolution in specific fields[15]. Such assessments provide empirical frameworks for stakeholders to prioritize research agendas, foster cross-disciplinary collaboration, and inform strategic scientific funding distribution[16]. Thus, systematic bibliometric investigation of PrEP offers multidimensional insights critical for identifying knowledge gaps, evaluating intervention efficacy, and guiding future research directions.

To the best of our knowledge, no bibliometric analysis of HIV PrEP has been conducted. Such an analysis could reveal research trends, collaboration patterns, and future directions. Thus, our objectives are to identify key journals, institutions, authors, and countries, map their collaboration networks, and synthesize core keywords in this field.

Materials and methods

Search strategy

An electronic literature search was conducted in March 2025 using the Web of Science Core Collection (WoSCC), a comprehensive database with bibliometric data widely used in bibliometric studies[17,18]. WoSCC served as the bibliographic data source. Widely regarded as a premier literature database, Web of Science is ideal for bibliometric analysis. The Science Citation Index Expanded (SCI-EXPANDED, 1900-present) was selected to ensure comprehensive and accurate search results.

Our primary search terms were: TS1 = ("Pre-Exposure Prophylaxis" OR "Pre Exposure Prophylaxis" OR "Pre-Exposure Prophylaxi" OR "Pre-Exposure Prophylaxis" OR "PrEP"), TS2 = ("Human Immunodeficiency Virus" OR "Acquired Immune Deficiency Syndrome Virus" OR "HIV" OR "AIDS").

Search parameters included document types (article, review) and English language restriction.

Data extraction

The full records and cited references of included publications were exported as tab-delimited text files. The following bibliometric parameters were extracted: titles, abstracts, keywords, authors, affiliations, countries or regions, year of publication, journal title, and references. Data were double-checked for accuracy, and any discrepancy was resolved through the re-examination of the original paper. Word derivatives were unified from the thesaurus files[19]. Data obtained by the WoSCC functions of "analyze results" were also collected.

Data analysis

This study used the Bibliometrix package in R software (version 4.4.3) and VOSviewer (version 1.6.20) for bibliometric analysis and the creation of scientific knowledge maps[20-22].

The Bibliometrix R package was mainly used for analyzing annual production, country-wise production, authors' ontributions over time, local impacts of sources based on the H index, and trending topics[23,24]. VOSviewer, a powerful bibliometric tool, was used to create knowledge maps based on web data and to visualize and explore these maps[25]. In the network visualization produced by VOSviewer, consistent colors indicate the same clusters, while node size reflects the frequency of co-occurrence. Total link strength (TLS) represents the cumulative weight of connections between nodes, visually depicted by the width of links, highlighting collaboration strength. This study leveraged VOSviewer for clustering analyses of countries, institutions, journals, authors, citations, and keywords due to its intuitive and clear performance in clustering tasks[26].

Results

Retrieval overview

A total of 5,273 (Fig. 1) documents were retrieved using the Web of Science platform. The main period of publication of the retrieved documents was from 1992 to 2025. The results of this retrieval included 679 journals, with an annual growth rate of 15.99% in the number of articles published, an average citation frequency of 23.39 times/document, and a total of 20,810 authors (Supplementary Table 1).

Annual distribution of publication counts

Figure 2 illustrates the distribution of the number of articles published in the research field of PrEP across different years. In the initial phase from 1992 to 2001, a total of 37 publications were recorded, which means that, on average, fewer than 4 manuscripts were published each year. Subsequently, from 2002 to 2011, the cumulative number of publications rose to 151, demonstrating a relatively slow growth in the volume of publications. In the final phase spanning from 2012 to 2022, the total number of articles reached 3,542. It should be noted that there was a peak value of 673 manuscripts in 2024.

National/regional publication output

The national publication output analysis showed that 118 countries/regions published articles in relevant fields. The distribution of publications by country is shown in table 1 and figure 3. The United States (n = 2,969) was the most productive country, accounting for 56.3% of the total publications, followed by the United Kingdom (n = 346, 6.6%), Australia (n = 226, 4.3%), China (n = 204, 3.9%), South Africa (n = 188, 3.6%), and Canada (n = 167, 3.2%). The results demonstrated that compared to other countries and regions, the United States had a much larger number of articles in this field, most of which were single-country publications, accounting for 71.6% of the total publications from the United States.

To present the international collaborative network, we utilized the module of co-authorship-country in VOSviewer. With at least 5 publications, a total of 76 prolific countries/regions formed a cooperative network. Of which, the United States, England, South Africa, Kenya, and Australia are large nodes with relatively thicker links. The United States had the highest degree of co-operation TLS (TLS = 2,644), and co-operated with 71 prolific countries. Of which, England (TLS = 1,176), and South Africa (TLS = 1,162) had a closer academic cooperation with the United States (Supplementary Fig. 1).

Institutions publishing

Among the top ten institutions with the highest number of publications (Table 2), the University of Washington (USA) leads with 540 contributions, closely followed by the University of California, San Francisco (USA) with 445 publications and Johns Hopkins University (USA) with 239 publications. Furthermore, in terms of scholarly impact, the University of California, San Francisco (USA) stands out as the most cited institution, accumulating a significant total of 22,602 citations.

In addition, the collaboration network among the top 71 institutions is presented, with the strongest collaborative ties highlighted between the University of Washington and the Kenya Medical Research Institute, and a TLS of 118 (Supplementary Fig. 2).

Top journals and co-cited journals

This study included 5,273 articles published in 679 journals. Table 3 lists the top 10 journals ranked by publication quantity and their latest 2024 impact factors (IF). These include *Journal of Acquired Immune Deficiency Syndromes* (AIDS) (n = 407, IF = 2.2), PLoS One (n = 341, IF = 2.6), *Journal of the International AIDS Society* (n = 289, IF = 4.9), AIDS patient care and sexually transmitted infections (STDs) (n = 174, IF = 3.8), and AIDS (n = 165, IF = 3.1).

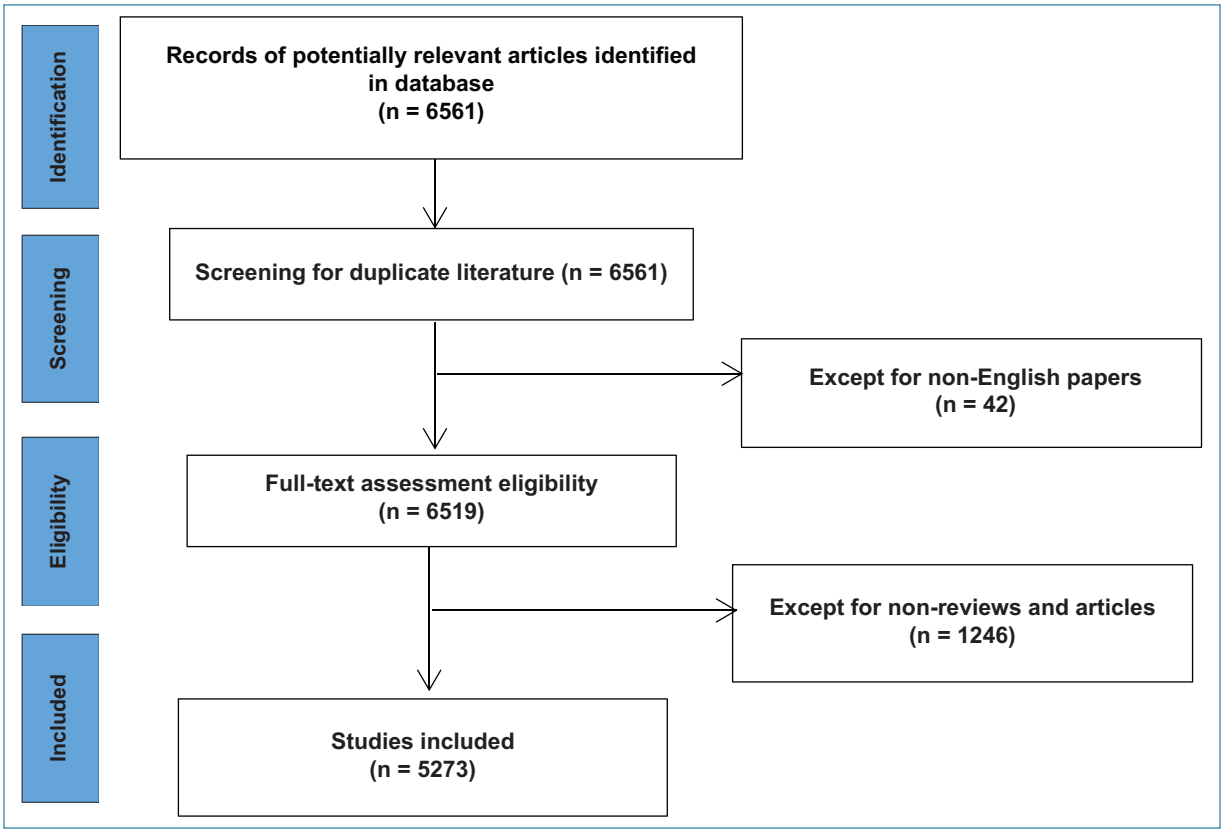

Figure 1. The flow chart of screening process.

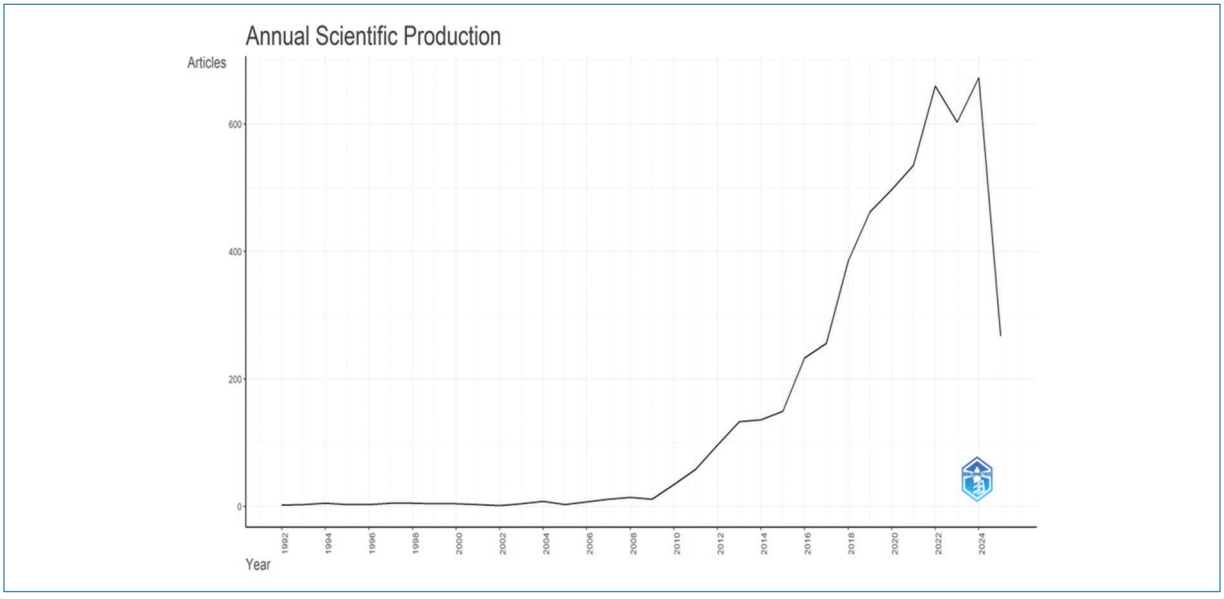

Figure 2. The distribution of annual article publications from 1992 to 2025.

Table 1. The top 15 productive countries related to PrEP

Rank	Country	Articles	Articles %	SCP	MCP	MCP %
1	USA	2969	56.3	2125	844	28.4
2	United Kingdom	346	6.6	170	176	50.9
3	Australia	226	4.3	155	71	31.4
4	China	204	3.9	129	75	36.8
5	South Africa	188	3.6	70	118	62.8
6	Canada	167	3.2	94	73	43.7
7	France	155	2.9	107	48	31
8	Brazil	111	2.1	64	47	42.3
9	Netherlands	94	1.8	54	40	42.6
10	Germany	73	1.4	43	30	41.1
11	Belgium	72	1.4	36	36	50
12	Thailand	58	1.1	17	41	70.7
13	Spain	56	1.1	45	11	19.6
14	Uganda	49	0.9	10	39	79.6
15	Italy	44	0.8	35	9	20.5

Single country publications.
PrEP: pre-exposure prophylaxis; MCP: multiple country publications.

Table 2. The top ten most productive institutions

Rank	The name of institution	Publications	Citations	Location
1	University of Washington	540	16898	The USA
2	University of California San Francisco	445	22602	The USA
3	Johns Hopkins University	256	10433	The USA
4	Emory University	239	6565	The USA
5	Harvard Medical School	238	6441	The USA
6	Centers for Disease Control and Prevention	225	9670	The USA
7	Columbia University	223	4289	The USA
8	London School of Hygiene and Tropical Medicine	221	5453	The UK
9	University of Witwatersrand	218	6851	South Africa
10	University of California Los Angeles	201	5466	The USA

We used R-Bibliometrix to measure journal impact based on the H-index. *Journal of AIDS*s had the highest H-index.

The publication trends over the years are presented, while the source titles of the co-citation analysis were analyzed using VOSviewer – with only journals that have accumulated at least 500 citations included in the study. 52 journals were identified based on their TLS. The top five journals with the highest TLS were *Journal of AIDS*s (TLS = 304,257), AIDS (TLS = 270,407), AIDS and Behavior (TLS = 265,941), *The New England Journal of Medicine* (TLS = 265,431), and PLoS One (TLS = 245,017) (Supplementary Fig. 3).

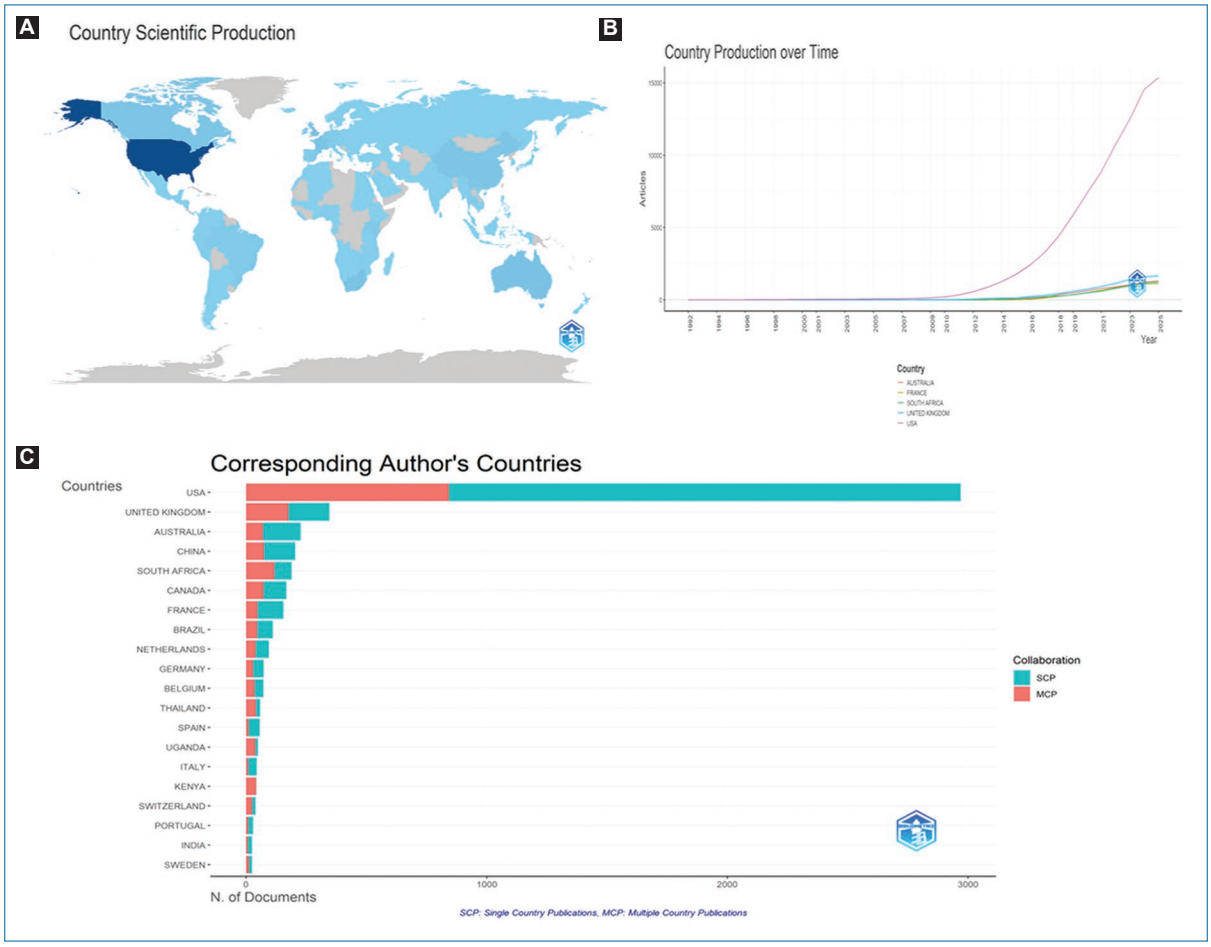

Figure 3. Analysis of the countries related to the publications in the PrEP Field. **A:** the geographical maps with Country Scientific Production. The darker the blue shade, the greater the amount of the articles produced; **B:** the number of articles published by various countries from 1992 to 2025; **C:** corresponding author's countries. SCP: single country publications; MCP: multiple country publications.

Authors and co-cited authors

Globally, 20,810 authors published articles in this field. The top 25 authors, based on publication quantity, were considered to be the core authors in this analysis. Over the past 33 years, metrics including the h-index, g-index, and m-index have been calculated. In this field, JM Baeten not only published the largest number of papers but also achieved the highest total citations, h-index, and g-index (Supplementary Table 2).

Notably, close collaborative relationships exist among these cited authors. Furthermore, authors with more than 200 co-citations are highlighted, with the top three being Grant RM (2,514 citations), Baeten JM (1,915 citations), and Molina JM (1,177 citations) (Supplementary Fig. 4).

Keywords and hotspots

To count the number of keyword occurrences more accurately, a thesaurus was used to merge keywords with similar meanings (Supplementary Table 3). A total of 20,810 authors' keywords were involved in the present study. 340 keywords with a threshold of over 20 in the co-occurrence network. The top 10 keywords were as follows: PrEP (n = 3,727), HIV (n = 1,268), men (n = 1,255), infection (n = 1,088), MSM (n = 958), sex (n = 888), risk (n = 853), adherence (n = 588), women (n = 596), and unitedstates (n = 476). Four kinds of colors represent different clusters of keywords. HIV in blue, including MSM, prevalence, and high-risk. PrEP in red, including men, sex, and risk. Woman in yellow, including adherence, impact, and cost-effectiveness. Infection in green, including transmission, antiretroviral

Table 3. The top ten most productive journals

Rank	Journal	Article counts	%	IF	Cites	Quartile
1	*Journal of Acquired Immune Deficiency Syndromes*	407	7.72	2.2	10845	Q3
2	*PLoS One*	341	6.47	2.6	8845	Q2
3	*Journal of The International AIDS Society*	289	5.48	4.9	6992	Q1
4	*AIDS Patient Care and STDS*	174	3.30	3.8	5335	Q1
5	*AIDS*	165	3.13	3.1	5847	Q2
6	*BMC Public Health*	151	2.86	3.6	1843	Q1
7	*International Journal of STD and AIDS*	129	2.45	1.3	1024	Q4
8	*Sexually Transmitted Infections*	129	2.45	2.9	1976	Q2
9	*Sexual Health*	123	2.33	2.2	1516	Q2
10	*Clinical Infectious Diseases*	114	2.16	7.3	4793	Q1

STDs: sexually transmitted infections; IF: impact factor.

prophylaxis, and tenofovir. Regarding research trends and focus, the prominent themes in this field were found to include cabotegravir, phase-3, care, HIV, men, PrEP, prevention, risk, infection, and antiretroviral prophylaxis, among others (Supplementary Fig. 5).

Discussion

General information

This bibliometric analysis illuminates the research landscape of HIV PrEP over the past 33 years, revealing a sustained growth in scholarly output (15.99% annual increase) and evolving scientific priorities. The exponential rise in publications mirrors the global urgency to address HIV prevention, particularly as PrEP emerges as a cornerstone strategy[27,28]. Key insights into this trajectory include geographical disparities, institutional dominance, journal preferences, and shifting research hotspots.

Geographical and institutional dynamics

The United States dominates PrEP research, contributing 56.3% of all publications. This primacy stems from its robust healthcare infrastructure, substantial federal funding (e.g., NIH grants), and high HIV prevalence among key populations (e.g., MSM and injection drug users)[29-31]. Collaborative networks further reinforce U.S. leadership: 71.6% of its publications are single-country studies, but international partnerships with nations such as the UK (TLS = 1,176) and South Africa (TLS = 1,162) highlight strategic alliances in global health initiatives.

China's rising presence (3.9% of publications) reflects growing national investment in HIV prevention, particularly after PrEP was prioritized in its 2020-2030 AIDS control plan[32,33]. Conversely, low-income regions like Uganda show high multi-country collaboration (79.6%), likely driven by international aid programs and clinical trials conducted by global organizations[34,35].

Journal landscape and research impact

Publications cluster in mid-impact journals (e.g., *journal of AIDS*s, IF = 2.2), with only 20% appearing in Q1 journals. This trend suggests that PrEP research prioritizes applied outcomes (e.g., clinical trial results, implementation strategies) over basic science, which may deter submissions to high-IF journals[36,37].

The scarcity of high-IF publications also signals a need for more translational research. For instance, while long-acting PrEP drugs (e.g., cabotegravir) show promise, their cost-effectiveness and global distribution remain understudied in top-tier journals[38,39].

Analysis of keywords and hotspots

Taking into account the clusters of keywords co-occurrence, frequency of keywords, and centrality of keywords, the research hotspots in this field were summarized as follows.

Applicable populations of PrEP

Precisely defining PrEP-eligible populations is a prerequisite for rational promotion and effective application. The WHO defines PrEP candidates as individuals facing HIV infection risk due to specific high-risk behaviors, regardless of local HIV prevalence, including MSM, injection drug users, sex workers, sexually active individuals, HIV-negative partners in serodiscordant couples, and those with recent STDs[40]. Not all HIV-negative individuals are suitable for PrEP – only those with high exposure risk[41]. Before initiating PrEP, HIV exposure risk assessment and medical evaluation must be conducted[42].

PrEP medications

First-generation PrEP drugs

This primarily includes oral nucleoside reverse transcriptase inhibitors (e.g., emtricitabine-tenofovir disoproxil fumarate [F/TDF] and emtricitabine-tenofovir alafenamide [F/TAF]). In 2012, the WHO recommended daily oral F/TDF for preventing HIV infection in HIV-negative partners of serodiscordant couples, expanding to MSM and injection drug users in 2015[43]. However, poor daily medication adherence among patients affects preventive efficacy, as shown in the VOICE[44], Partners PrEP[45], and iPrEx[46] trials.

Second-generation PrEP drugs

Featuring longer half-lives and lower dosing frequencies to improve adherence. Examples include: The monthly dapivirine vaginal ring, approved by the WHO for high-risk women in 2021[47]. Cabotegravir long-acting, administered every 2 months, showed superior prevention efficacy than daily oral F/TDF in HPTN083[48] and HPTN084[49] trials, and was recommended by the WHO in 2022. Novel nucleoside reverse transcriptase transport inhibitor islatravir[50] and the broadly neutralizing antibody VRC01 (administered via intravenous infusion every 8 weeks)[51] are also under trial evaluation.

Barriers and challenges of PrEP

Lack of awareness

There is a notable lack of awareness regarding PrEP among both potential users and healthcare professionals. Specifically, young men who have MSM demonstrate a relatively low level of awareness about PrEP[52]. Moreover, social media platforms, which play a significant role in information dissemination, lack authoritative science popularization content related to PrEP[53]. This dearth of accurate information has led to various misconceptions about PrEP, which in turn negatively impacts the willingness of potential users to adopt it[54]. Concurrently, some healthcare professionals do not possess in-depth knowledge about PrEP[55,56]. This deficiency hampers their ability to provide accurate and comprehensive counseling to patients, further exacerbating the issue of low PrEP uptake and proper utilization.

Economic pressure

In China, PrEP is not yet covered by medical insurance, imposing high out-of-pocket costs – particularly burdensome for students and low-income groups[57]. While free PrEP would alleviate patient costs, it pressures healthcare institutions and related departments[58]. Short-term PrEP implementation requires substantial funding, but long-term widespread use reduces HIV infections and subsequent treatment costs, yielding socioeconomic benefits[59]. Governments and stakeholders should increase financial support and explore diversified funding channels.

Privacy concerns

Since PrEP drugs are also used for HIV treatment, individuals prioritize privacy. High-risk groups may avoid PrEP due to stigma[60]. Women fear disclosing PrEP use to intimate partners, and social discrimination against sexual minorities amplifies privacy fears[61]. Regular clinic visits and daily medication evoke shame and inconvenience.

Compensatory effect

A key controversy with PrEP use is the potential "compensatory effect" (behavioral disinhibition), where reduced perceived HIV risk may drive riskier sexual behaviors and higher STI rates. As noted in relevant studies[62,63], this effect is linked to behavioral shifts such as less condom use, more sexual partners, and reduced serosorting. While PrEP is effective for HIV prevention and engages high-risk groups, targeted interventions such as counseling and regular screening are necessary to address STI increases associated with the "compensatory effect."

Research trends

Keyword co-occurrence analysis and topic distribution diagrams show high frequency and clustering of some research areas in PrEP literature, indicating sustained academic attention. Some research areas are identified as trends as they tackle key challenges in maximizing PrEP's preventive efficacy and boosting its global implementation.

Long-acting drug development

Long-acting PrEP offers advantages as the optimal future HIV prevention strategy. Gilead Sciences' PURPOSE 1[64] and PURPOSE 2[65] phase 3 trials showed that semiannual lenacapavir injections significantly prevented HIV infection, with good overall tolerability compared to daily oral F/TDF. However, whether lenacapavir can rewrite the epidemic trajectory depends on breaking price barriers, policy support, and equitable global distribution[66-68].

Awareness enhancement

Public health education must be strengthened through diversified campaigns to popularize PrEP knowledge[69-71]. For healthcare professionals, systematic training programs should deepen understanding and improve service capabilities[72].

Multi-sectoral collaboration

To maximize the preventive effect of PrEP, cross-sectoral collaboration is essential; however, practical challenges persist, including inadequate communication, ambiguous responsibilities, and inconsistent actions[73,74]. To address these issues, sound coordination mechanisms should be established to clarify roles and responsibilities, enhance information sharing, and facilitate joint efforts to promote widespread PrEP adoption[75].

Limitations

This analysis has several limitations. First, relying only on the WoSCC may miss studies, causing bias. Second, excluding non-English research ignores valuable work from other regions. Third, while two authors carefully reviewed keyword merging, some errors or omissions may remain.

Conclusion

This study presents the first bibliometric analysis of HIV PrEP research, identifying core research foci including long-acting drug development, interventions for high-risk groups, and implementation challenges. It reveals an evolving trend in research priorities, shifting from early efficacy validation via clinical trials toward real-world implementation and, recently, long-acting technologies and health equity. The findings suggest that governments and global organizations should enhance support for long-acting PrEP development, integrate PrEP into healthcare systems, strengthen awareness campaigns, and establish multi-sectoral collaboration to maximize its role in HIV prevention.

Supplementary data

Supplementary data are available at DOI: 10.24875/AIDSRev.25000012. These data are provided by the corresponding author and published online for the benefit of the reader. The contents of supplementary data are the sole responsibility of the authors.

Author contributions

W. Liu contributed to the study design and critical revision. C. Huang, L. Zhang, M. Chen, and Y. Sun, participated in research design, data analysis, and data interpretation. C. Huang and L. Zhang were major contributors to writing the manuscript. Y. Sun and M. Cheng participated in the editing of the paper. All authors read and approved the final manuscript.

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Conflicts of interest

None.

Ethical considerations

Protection of humans and animals. The authors declare that no experiments involving humans or animals were conducted for this research.

Confidentiality, informed consent, and ethical approval. The study does not involve patient personal

data nor requires ethical approval. The SAGER guidelines do not apply.

Declaration on the use of artificial intelligence. The authors declare that no generative artificial intelligence was used in the writing of this manuscript.

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