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A Scientometric Analysis of Sickle Cell Anemia from Scopus, PubMed, and Science Direct

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Abstract

Sickle Cell Anemia (SCA) remains a major global health challenge, with high prevalence in Africa and India. This study aims to explore global research trends, major scientific contributions, and the role of Ayurvedic medicine in the management of SCA. A scientometric analysis was performed using databases such as Scopus, PubMed, and ScienceDirect. The findings highlight leading research countries, key publication trends, impactful studies, and the growing interest in integrative approaches including Ayurved.

We aimed to conduct a thorough bibliometric and scientometric analysis of the literature on sickle cell anemia.

Search was conducted across three major databases: Scopus, PubMed, and ScienceDirect. Keywords used included "Sickle cell anemia and Ayurved", Sickle cell disease and Ayurveda"," Sickle cell anemia and herbal medicine"

Publications from 2000 to 2023 were analysed for publication trends, citation impact, top journals, and leading countries in SCA research.

Research on sickle cell anemia continues to evolve, driven by advancements in genetics, molecular biology, and clinical practices. The collaborative efforts of researchers worldwide are paving the way for innovative treatments and improved patient care, offering hope for those affected by this challenging condition. Studies suggest that Ayurvedic

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medicines may have mild efficacy in reducing oxidative stress and improving red blood cell health in SCA patients. However, clinical trials with rigorous designs and larger sample sizes are needed to confirm these benefits.

Key words : Sickle Cell Anemia, Ayurveda, Herbal Medicine, Bibliometric Analysis, Scientiometric Analysis, Public Health

Genetic disorders affecting hemoglobin structure or production are called as Hemaglob inopathies. They place a significant strain on families and the nation's healthcare system as a major source of morbidity and mortality. Another hemoglobin condition that necessitates lifetime care and raises the morbidity and mortality rate in infants and children is sickle cell disease (SCD). Sickle Cell Disease (HbSS), commonly known as Sickle Cell Anemia (SCA), is one of the sickle cell syndromes. SCD is brought on by the inheritance of two defective HbS genes, one from each parent or the HbE or β thalassemia gene from one parent.[12] It is condition that results in haemolysis and long-term organ damage. Haemolytic anemia, is a chronic condition that causes organ damage, pain crises and blood transfusions.[12] This condition causes body to Sickled shape red blood cells to deliver oxygen, which can lead to Pain crisis such as discomfort in the bones, stomach, or chest. When sickle cells obstruct blood arteries causes Acute chest syndrome and Organ damage.[1] As of 2021, Globally, 7.74 million people with sickle cell disease (SCD)[8] In India Sickle Cell Disease (SCD): 1.17%, Sickle Cell Trait (Carrier): 5.9% mostly found in General and tribal populations across multiple Indian states. Highest prevalence seen among tribal groups in central India (Madhya Pradesh, Chhattisgarh, Maharashtra, Odisha, Gujarat, Jharkhand) Annually, approximately 300,000 children are born globally with Sickle Cell Anemia, with the majority of cases occurring in sub-Saharan Africa. In India, the disease remains a significant public health concern, with an estimated 42,000 new cases annually, particularly among tribal populations.[7]

Data Sources :

The bibliometric analysis utilized three major research databases: Scopus, PubMed, and Science Direct. Science Direct, operated by Elsevier (Netherlands), is a comprehensive bibliographic platform hosting scientific and medical literature across a wide range of disciplines[3]. Over 25,100 titles from more than 5,000 foreign publishers are included in the source-neutral abstract and citation database Scopus, which is also run by Elsevier. It offers a thorough and trustworthy summary of worldwide research findings in a variety of disciplines, including medicine.[3] PubMed, maintained by the U.S. National Library of Medicine, was also searched to ensure coverage of biomedical literature from peer-reviewed journals.

Search Strategy :

A systematic bibliometric search was conducted across the three databases. The keywords and combinations used included:

"Sickle cell anemia and Ayurved"

"Sickle cell anemia and herbal medicine"
"Sickle cell disease and Ayurved"

Boolean operators (AND) were applied to refine the search queries, ensuring comprehensive retrieval of relevant publications. The search period was restricted to January 2000 – December 2023, capturing two decades of research output to assess both long-term and emerging trends.

Inclusion and Exclusion Criteria :

Inclusion : Peer-reviewed articles, review papers, clinical studies, bibliometric analyses, and case reports related to Sickle Cell Anemia (SCA), Ayurveda, herbal medicine.

Exclusion : Non-peer-reviewed literature, editorials without data, conference abstracts and publications unrelated to hematology or sickle cell disease.

Data Extraction and Analysis :

The bibliometric data extracted included :

1. **Publication trends :** Annual research output over the last two decades.
2. **Citation analysis:** H-index scores and average citations per publication are used to evaluate the impact of research.
3. **Top journals:** journals that have the most papers and citations in this field.
4. **Geographic distribution:** top nations in terms of the number of publications and the influence of citations.
5. **Research focus:** study classification according to subjects like gene therapy, herbal remedies, and Ayurvedic methods.
6. Data were cross-verified between Scopus and Science Direct to ensure accuracy. Results were visualized using **charts, graphs, and tables** to present publication metrics and trends.

Public Health Burden of Sickle Cell Anemia :

As was indicated in the introduction, sickle cell anemia affects more than 300,000 babies annually worldwide, with the bulk of instances occurring in sub-Saharan Africa. The disease continues to be a significant public health concern in India, particularly among tribal populations, with an estimated 42,000 new cases annually.[7]

Top Research Nations:

In terms of publication volume and citation effect, the United States is in the lead, followed by India and the United Kingdom. These nations make the largest contributions to research on the pathophysiology of diseases, novel treatments, and public health initiatives. Countries that provide the most: USA > UK > India.

Publication and Citation Trends :

Publication volume has steadily increased over the past 20 years.

Highly cited studies in the field of sickle cell anemia focus on three major therapeutic
advancements: Hydroxyurea therapy[5]
Gene therapy[13]

Fetal hemoglobin augmentation[2,5]

Citation Analysis of Publications by Country:

The citation matrix reveals the comparative impact of sickle cell anemia research among leading countries:

USA leads significantly with 1,500 publications and an average citation rate of 20.5, reflecting both a high research volume and strong global influence.

The United Kingdom follows with 800 publications and an average citation rate of 18.7, indicating impactful contributions with a moderate publication volume.

India, while contributing fewer publications (600), maintains a respectable average citation rate of 15.2, highlighting growing academic relevance, especially in the context of tribal and regional health interventions.

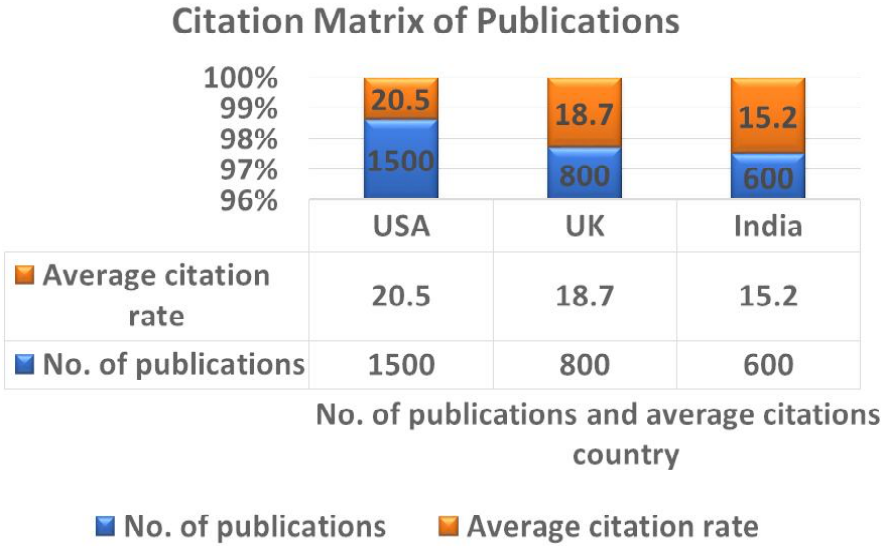
This data suggests that the USA not only publishes the most but also garners the highest citations per paper, signifying leadership in both quantity and quality. The UK and India also demonstrate notable academic engagement in the field of SCA.

Top Journals :

Rank	Journal Name
1	*Blood*[5]
2	*The Lancet Haematology*[7]
3	*The Indian Journal of Hematology and Blood Transfusion*[4]

1. ***Blood :*** (Impact Factor: 22.113)
   This journal publishes highly cited work related to genetic therapies and clinical trials, especially involving novel treatment approaches and molecular interventions.
2. ***The Lancet :*** (Impact Factor: 79.321)
   Known for its high-impact publications, *The Lancet* includes major studies on public

Top Journals and Their Contributions to Sickle Cell Anemia Research :



health interventions and treatment outcomes in global sickle cell disease management.

3. ***The Indian Journal of Hematology and Blood Transfusion :*** (Impact Factor: 1.220) This journal contributes valuable research focused on epidemiology and clinical management of sickle cell anemia, particularly in the Indian context.

Ayurveda and Herbal Research :

Several studies have attempted to bridge Ayurveda and modern research in SCA. Ayurvedic concepts such as Pandu Roga have been compared with anemia in SCA patients. Herbs with antioxidant, adaptogenic, and hematopoietic activity have been explored.

Herbs studied:

Aloe vera (Aloe vera L.)[18]
Lemongrass (Cymbopogon citratus) [18]
Pigeon pea (Cajanus cajan)[18]
Garlic (Allium sativum)[18]
Ashwagandha (Withania somnifera)[6]
Amla (Phyllanthus emblica)[6]
Turmeric (Curcuma longa)[18]

Proposed mechanisms:

Antioxidant protection of RBCs[18,6]
Reduction of oxidative stress[6]
Enhancement of hemoglobin stability[11]
Improved microcirculation[6]

Herbal medicine research :

Several herbal extracts have demonstrated potential in the supportive management of sickle cell anemia (SCA). Notably, combination therapies involving botanicals such as pigeon pea (*Cajanus cajan*), sweet orange (*Citrus sinensis*), grains of selim (*Xylopia aethiopica*), and rapeko (*Euphorbia hirta*) have been traditionally used to manage pain, swelling, and sickling crises in affected individuals[6,18].

Furthermore, oxidative stress, a key factor in the pathogenesis of sickled erythrocytes, has been demonstrated to be reduced by antioxidant-rich herbs such as Moringa oleifera, Silybum marianum (milk thistle), and Cissampelos pareira[6,11]. By assisting in the neutralization of free radicals, these substances shield red blood cells from oxidative damage.

Additionally, anti-inflammatory botanicals including Boswellia serrata and Zingiber officinale (ginger) have shown analgesic and anti- inflammatory properties, which may aid in managing chronic inflammation and excruciating Vaso-occlusive episodes in SCA[11,14].

Despite these encouraging results, the primary obstacle to Ayurvedic and herbal-based research in SCA is the absence of large-scale, high-quality randomized controlled trials (RCTs). With little uniformity in dosage, formulation, and result evaluation, the majority of current research is preclinical, in vitro, or small observational[16,17]. Therefore, additional thorough clinical trials are required to verify safety, efficacy, and incorporation into conventional treatment regimens.

Methods of Action of Herbal and Ayurvedic Treatments for Sickle Cell Anemia :

Ayurvedic and herbal remedies have the ability to treat sickle cell anemia (SCA)

through a number of underlying mechanisms of action.

1. ***Regulation of Redox :*** Flavonoids, polyphenols, and other antioxidants are abundant in many Ayurvedic plants, including Silybum marianum, Moringa oleifera, and Phyllanthus emblica (Amla). By lowering oxidative stress, which is a major cause of hemolysis and red blood cell sickling in SCA, these bioactive substances aid in the neutralization of free radicals[6,18].

Erythropoiesis Stimulation*:* It has long been believed that some Ayurvedic formulations, such as Lauha Bhasma and Mandura Bhasma, as well as herbal combinations like Triphala and Punarnavadi Mandura, might promote the synthesis of red blood cells. Although Ayurvedic practitioners frequently make this therapeutic assumption, there is currently little scientific support for it, and controlled trials are needed to confirm it[16].

Table-1. Summary of Publications on Sickle Cell Anemia & Herbal Medicine form Pubmed Database.[10]

Category	Number of Publications
Abstracts	80
Full Text (Paid + Free)	77
Free Full Text	35
Paid Articles	42
Associated Data Sets	25
Clinical Trials	3
Randomized Controlled Trials (RCTs)	2

Pain and Inflammation Management: The tridosha hypothesis, which specifically addresses vitiated Vata and Pitta doshas, is the foundation of the Ayurvedic treatment to pain in SCA. Herbs having anti-inflammatory and analgesic qualities, like ginger (Zingiber officinale), boswellia serrata, and guduchi (Tinospora cordifolia), may help lessen tissue inflammation, swelling, and pain related to vaso-occlusive events[11,14].

Table-2. Publication Types on Science Direct for Sickle Cell Anemia & Herbal Medicine[3,10]

Category	Number of Publications
Book Chapters	223
Review Articles	130
Paid Articles	42
Open Access Articles	98
Abstracts	23
Case Reports	3
Discussions	15

Sickle cell anemia (SCA) is a major worldwide health concern, particularly in sub-Saharan Africa and India, where the disease burden is highest[8,15]. Despite advancements in hydroxyurea therapy, transfusion techniques, and novel therapeutic approaches like gene therapy, there are still substantial gaps in accessibility, cost, and long-term outcomes[7,12]. Alongside these developments, studies are being done on the possible hematological, anti-inflammatory, and antioxidant benefits of herbal and Ayurvedic remedies, which could be useful in the management of illness[16,18]. In order to bridge traditional knowledge with current biological research, the current study evaluates *Tapyadi Loha's* therapeutic potential in SCA.

Future Direction :

Research on sickle cell anemia (SCA)

has a bright future because both traditional medicine and contemporary science are influencing the development of new treatment approaches. The next generation of treatment and global management is anticipated to be shaped by a number of important topics.

Personalized Medicine :

Emerging genomic technologies are paving the way for individualized treatment strategies. By analyzing a patient's specific genetic profile, clinicians can tailor therapies such as hydroxyurea dosing, transfusion protocols, and gene therapies for optimal outcomes[2]. Advances in pharmacogenomics are expected to improve both treatment efficacy and safety in SCA care[7]. And According to patient's prakriti and balya ayurvedic medicine should be prescribed.

Integrative Approaches :

There is growing recognition of the potential value in combining traditional systems like Ayurveda with modern medical treatments. Herbal formulations with antioxidant, anti-inflammatory, and hematopoietic properties may serve as adjunct therapies in reducing oxidative stress and enhancing red blood cell health[11,18]. Future research should aim to integrate Ayurvedic *Rasayana* chikitsa into standard care, especially in tribal and rural populations where accessibility to advanced treatments may be limited.

Global Health and Equity Initiatives :

Addressing health disparities in SCD is a major priority. Efforts must focus on scaling screening programs, preventive care, and public education in high-prevalence regions like sub-Saharan Africa and India[7,8,15]. Expanded international collaborations and policy-driven programs such as the WHO sickle cell strategy and India's Sickle Cell Elimination Mission 2047 are vital to improving access and outcomes globally.

Curative Therapies and Gene Editing :

Continued innovation in gene therapy and CRISPR-based gene editing holds promise for potentially curing SCD. The safety and effectiveness of such methods in altering or fixing the faulty β-globin gene are being evaluated in ongoing clinical trials[4]. One of the fundamental objectives for global health systems is still to make these technologies accessible and inexpensive. Significant advancements in genetics, molecular biology, and clinical practice have contributed to ongoing research on sickle cell anemia (SCA). New therapeutic medicines, enhanced screening methods, and curative measures like gene therapy and hematopoietic stem cell transplantation have all resulted from international cooperation[8,12]. These developments are changing the prognosis for many who suffer from this long-term and frequently crippling illness.

At the same time, new research indicates that herbal and Ayurvedic remedies might help manage SCA. Some herbs, including *Silybum marianum, Moringa oleifera,* and *Phyllanthus emblica*, have shown hematoprotective and antioxidant properties that may help improve red blood cell integrity and lessen oxidative stress[3,10]. Ayurvedic formulations such as *Tapyadi Loha and Punarnavadi Mandura* have shown promising effects in

clinical evaluations, particularly in tribal groups where access to traditional medicines may be limited[7]. The majority of these investigations, however, are preclinical or small-scale, underscoring the necessity of thorough, large-sample randomized controlled trials to verify their safety and effectiveness[7,10].

Recent advances in the management of sickle cell anemia have led to the development of several disease-modifying and potentially curative treatment strategies. Approaches such as hydroxyurea therapy, improved blood transfusion protocols, hemato-poietic stem cell transplantation, and emerging gene-based therapies have significantly improved patient survival and quality of life. Despite these developments, many patients, particularly in low-resource settings, still face challenges related to accessibility, affordability, and long-term treatment sustainability. In this context, integrative healthcare models that combine validated Ayurvedic interventions with evidence-based allopathic treatments may offer a more holistic and culturally acceptable approach to disease management. Ayurveda emphasizes strengthening the body, improving immunity, and restoring physiological balance through herbal formulations, dietary regulation, and lifestyle modifications. Certain Ayurvedic herbs and formulations with antioxidant, anti-inflammatory, and hematopoietic properties may support red blood cell health and reduce oxidative stress associated with sickle cell anemia. When used alongside conventional medical care under proper clinical supervision, these traditional therapies could potentially improve overall patient outcomes and quality of life. However, the scientific evidence supporting many Ayurvedic interventions remains limited. Therefore, future research should prioritize well-designed clinical trials with larger sample sizes and standardized methodologies to thoroughly evaluate the safety, efficacy, and therapeutic role of Ayurveda in the comprehensive management of sickle cell anemia.

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