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World Cataract Research: A Scientometric Analysis of Publications Output during 2002-11

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Abstract

Objectives: The study analyses the global publications output in cataract research during 2002-11 on several parameters including contribution & citation impact of top 15 most productive countries, different types of cataract research, research output by different population age groups, subject-wise break-up of research output, relatedness of various diseases to cataract research, research contribution and impact of top 15 institutions and authors and productivity of the top 20 journals.

Methods: The Scopus Citation Database has been used to retrieve the data for 10 years (2002-11) by searching the keywords "cataract" in the combined Title, Abstract and Keywords field.

Results: The world publication output in cataract research consisted of 27053 papers during 2002-11, which increased from 2025 papers in 2002 to 3080 papers in 2011, witnessing an annual average growth rate of 4.89%. The average citation impact per paper registered by world publications was 6.94 during 2002-11, which decreased from 7.82 during 2002-06 to 5.21 during 2007-11

Conclusions: Cataract is a significant and increasing global problem. The challenges are to prevent or delay cataract formation and cure that which occurs. Preventive interventions must be identified, perfected and delivered through research changes in government policy and legislation and modification of community and individual behavior.

Key Words: Eye**, C**ataract, Research output,Publications,Scientometrics

Introduction

Cataract, defined by the World Health Organization (WHO) as a visual acuity (VA) of less than 3/60 in the better eye, is the leading cause of blindness in the world. It affects approximately 20 million people, 90% of them in low- and middle-income countries. According to the latest assessment, cataract is responsible for 51% of world blindness. Although cataracts can be surgically removed, in many countries barriers exist that prevent patients to access surgery. Cataract remains the leading cause of blindness. As people in the world live longer, the number of people with cataract is anticipated to grow. Cataract is also an important cause of low vision in both developed and developing countries[1].

Cataracts are changes in clarity of the natural lens inside the eye that gradually degrade visual quality. The natural lens sits behind the colored part of the eye (iris) in the area of the pupil, and cannot be directly seen with the naked eye unless it becomes extremely cloudy. The lens plays a crucial role in focusing unimpeded light on the retina at the back of the eye. The retina transforms light to a neurologic signal that the brain interprets as vision. Significant cataracts block and distort light passing through the lens, causing visual symptoms and complaints. The term *cataract* is derived from the Greek word *cataractos*, which describes rapidly running water. When water is turbulent, it is transformed from a clear medium to white and cloudy. Keen Greek observers noticed similar-appearing changes in the eye and attributed visual loss from "cataracts" as an accumulation of this turbulent fluid, having no knowledge of the anatomy of the eye or the status or importance of the lens[2].

The lens maintains its clarity because of its architectural structure and composition. The lens fibers are laid down in specific arrays and are composed mainly of crystalline proteins. When biochemical or physicochemical changes develop that disrupt the architecture or result in formation of molecules larger than 1,000 nm (10,000 Å), the affected area loses its transparency and opacity results. The resulting opacity, however, needs to be located at or near the visual axis for it to affect vision and become clinically important. Very often, peripheral cataracts develop without affecting the visual acuity of the patient and are therefore considered clinically benign. These opacities may exist for many years, even decades, without necessitating any treatment other than optical correction[3].

In terms of etiology, cataracts may be classified as follows:

Age Related Cataract (Senile Cataract) - Age-related cataracts appear in late adulthood and cause painless progressive loss of vision over the course of several years. Of the various clinical types of cataracts, the majority consist of age-related or senile cataracts. It has been estimated that more than 75% of persons older than 75 years have lens opacities. The lens is composed of layers like an onion. The outermost is the capsule. The layer inside the capsule is the cortex, and the innermost layer is the nucleus.

A cataract may develop in any of these areas and is described based on its location in the lens: (i) A nuclear cataract is located in the center of the lens. The nucleus tends to darken changing from clear to yellow and sometimes brown, (ii) A cortical cataract affects the layer of the lens surrounding the nucleus. It is identified by its unique wedge or spoke appearance and (iii) A posterior capsular cataract is found in the back outer layer of the lens. This type often develops more rapid[3-4].

Congenital and Juvenile Cataract - Congenital cataracts are detected at birth, whereas juvenile cataracts develop during the first 12 years of life. Both range from mild and benign to advanced and sight-threatening and are the third most common cause of blindness in children. Approximately one third of congenital and juvenile cataracts are inherited and a wide degree of variation is seen in the morphologic characteristics of these cataracts[3].

Traumatic Cataract - Cataracts can occur secondary to trauma to the lens. The morphologic characteristics differ between cataracts due to blunt trauma and cataracts secondary to penetrating trauma. Cataracts secondary to blunt trauma often have a rosette-shaped appearance or are of the PSC variety. In cataracts secondary to penetrating trauma, the size of the opening in the lens capsule determines the morphology of the cataract. When the opening is large, the whole lens is cataractous, when the opening is small, it may sometimes seal by itself and leave behind an opacity that is localized to the site of penetration.

Cataract Associated with Intraocular Diseases - Cataracts can occur secondary to a large number of intraocular diseases and these are often referred to as complicated cataracts. Intraocular inflammation is the most common cause of this type of cataract. These cataracts are typically of the PSC variety. PSCs seen in retinitis pigmentosa, gyrate atrophy, and Usher's syndrome show finger-like projections. In persistent hyperplastic primary vitreous, the PSC is often associated with abnormal blood vessels from the hyaloid system that arborize from the posterior pole of the lens. Cataracts seen in retinal anoxia and anterior segment necrosis are thought to occur due to interference with the nutrient supplies of the lens. This leads to decreased anabolism, increased catabolism, increased acidity, and necrosis. The cataracts in these conditions are also of the PSC type. An acute increase in intraocular pressure can cause focal necrosis of the subcapsular epithelium and localized, fleck-like opacities (*glaucomflecken*). These opacities are initially located immediately under the capsule, but with the laying down of new fibers, they slowly get buried in the lens; their presence indicates that the patient has had an acute increase in intraocular pressure. Premature occurrence of nuclear and PSC-type cataracts have been described in eyes with high myopia. In patients with aniridia, Peters' anomaly, and neurofibromatosis type 2, both PSCs and cortical cataracts may occur[3].

Cataract Associated with Systemic Diseases - Systemic conditions associated with cataract formation can be grouped into five broad categories: (i) Metabolic disorders, (ii) Skin disease, (iii) Connective tissue/skeletal disorders; (iv) Renal disease and (v) Central nervous system disorders[3].

Cataract caused by Noxious Agents: Radiation and Pharmaceuticals – (i) Cataracts due to Ionizing Radiation **-** Continuous exposure to many of the wavelengths in the electromagnetic spectrum (*e.g.*, x-rays, -ultra-violet rays, microwaves, infrared rays) can cause cataracts. Often, a latent period of 9 to 12 months exists between ionizing radiation exposure and onset of cataract. These cataracts are PSCs and classically show multiple vacuoles as well as an evenly feathery appearance and web-like fringes. Ionizing radiation affects the germinative equatorial epithelium. The damaged cells form an abnormal plaque, which first appears at the posterior pole and progressively shows enlargement; (ii) Cataracts Secondary to Pharmaceutical Agents **-** A large number of pharmaceuticals are known to induce cataracts. The following is a list of the more commonly used pharmaceuticals, along with the characteristics of their associated cataracts; (i) Corticosteroids, (ii) Hydrocarbons and substituted hydrocarbons, (iii) Miotics, (iv) Phenothiazines and (v) Psoralen-ultraviolet A (PUVA) therapy[3].

Literature Review

Several scientometric studies were conducted on world, regional and country distribution of ophthalmology and visual science literature. Among these studies, Mandal,, Benson & Fraser[5] studied the contribution of different regions to ophthalmic literature during 1998-2000. Ohba[6] analyzed 55,591 world ophthalmic publications during 1988-2002: North America (49.5% share), Western Europe (31.3%), Asia and Oceania (15.1%), Middle East (2.2%), Central and South America (0.85%), Eastern Europe (0.53%) and Africa (0.47%). The research productivity was also compared with economic productivity as defined by GDP and clinical research in terms of randomized controlled trials. Guerin, Flynn, Brady & O'Brien[7] studied 7754 world ophthalmology publications from 67 countries from 2002-2006, and output was also analyzed in relation to population demographics and research expenditure.

In terms of regional distribution, Ragghianti, Rosa, Martíns & Gallo[8] took a comparative study of 1216 scientific publications in ophthalmology & visual sciences among 5 Latin America countries during 1995-2004, with highest average annual production (82.4) in Brazil, followed by Argentina (31.0), Chile (6.4), Uruguay (1.6), and Paraguay (0.2). The research publications almost tripled from 1995 to 2004. Research on humans showed a significant increase in Argentina and Brazil. Ugolini, Cimmino, Casilli & Mela[9] compared European Union countries contribution to ophthalmology literature from 1995-1997. The EU research impact was compared with that produced in other countries and trends of research are highlighted through the keywords analysis. Davies, Wilson & Hood[10] compared the Australian research productivity in ophthalmology & visual science with countries of similar scientific stature, or of language and Commonwealth status

In terms of country studies, Davies, Wilson & Hood[10] studied Australia's research contribution in vision science domain during 1991-95, using data from combined ISI's three citation indexes, SCI, SSCI, & AHCI. Its publication frequency vis--vis the world, its collaboration with authors from other nations and the journals in which it frequently published are shown. Zou, Wu & Wu[11] analyzed 961 China publications in ophthalmology, optometry & visual science, using SCI database during 2000–2007. The majority of researchers output came from university hospitals (53%). Around 21% of the publications involved international collaboration. The largest number of papers was in the area of retina. Kumaragurupari, Sieving & Lalitha[12] studied 2163 Indian publications in ophthalmology & vision science during 2001-06 to assess publications productivity, trends in journal choice, publication types, research funding and collaborative research Clinical science articles were most frequently published whereas basic science the least. Publications resulting from international collaborations increased from 3% in 2001 to 8% in 2006. The largest number of publications corresponds to the most common cause of bilateral blindness in India, cataract.

Only few scientometric studies on cataract were published in the past. For example, Tsai, Wang & Ho[13] investigated the quantity and quality of world research output (8186 papers) in cataract using SCI database from 1991 to 2005 focusing on growth, productivity, authorship pattern, international collaboration and subject trends using keywords. Fan & McGhee[14] identified the most published authors on the topics of 'cataract' and 'LASIK', the journals in which they publish, and the citation patterns of the most-cited articles by these authors over a 5-year publication period (2000-04). Science Citation Index Expanded (SCI) was used to identify the 30 most-published authors in 'cataract' and 'laser in situ keratomileusis' (LASIK). The USA and Australia together were the source of more than half of the most-published authors on cataract and LASIK and the majority of articles published by the 30 most prolific authors were published in only 10 journals. The impact factors of the publication journals preferred by these authors are influenced by the article citation counts, not vice versa. Wu, Xu & Wang[15] explored the distribution and research articles (45868) on cataract as published in PubMed database from 1813-2010. From 1946 to 2010, the number of research papers by year approximated followed a straight line ($Y=598.71X-689.92$, $R^2=0.9746$). The cataract literature was primarily in English (34655, 75.6%). Around 10299 papers (23%) were retrieved in 22 journals on ophthalmology (SCI-indexed).Chinese cataract literatures in PubMed appeared in 1946 and increased obviously since 1961. Chinese publications (732) were ranked at 7th rank with 1.59% share.

Objectives

The main objective of this study is to analyze the global research output in cataract research during 2002-11, with a view : (i) To study the world research output, its growth, rank and global publications share and citation impact of top 15 countries, (ii) To study the output and impact of different types of cataract

research, by different sub-fields and by different age group of population and relatedness of various specific diseases to cataract research, (iii) To study the publications productivity and impact of leading institutions and authors and (v) To study the pattern of communication in most productive journals.

Methodologies and Source of Data

This study used Scopus International Database [http://www.scopus.com/search/] to extract relevant data on global cataract research and top 15 most productive countries for the 10 years (2002-11). An advanced search strategy involving "cataract" as the keyword was used to search and download data using Title, Abstract and Keywords fields together, resulting in downloading of 27053 records related to global cataract research. For generating different types of cataract research, separate search strategies were developed using different keywords, one or more. Cataract research output was classified according to population by age groups based on keywords, such as child, adolescents, adults, middle aged and aged 80 & over: For analyzing papers by sub-fields, database classification as provided in Scopus database has been used. For analyzing significant institutions, authors and journals, separate search strategies were developed, which later combined with the main string lead to the generation of the desired output. For citations data, three years, two years, one year and zero year citation windows have been used for computing average citations per paper in cataract research during 2002-08, 2009, 2010 and 2011. For example, for papers published in 2002, citation window is three years from 2002-05. For papers published in 2009, citation window is two years from 2009-11, and for papers published in 2010 citation window is one year 2010-11.

Analysis

Global Publication Share & Rank.

The global publication share of the top 15 most productive countries in cataract research varies from 1.29% to 24.08% during 2002-11. The United States tops the list, with a publication share of 24.08% during 2002-11. The United Kingdom ranks second (with 9.66% share), followed by China (8.16% share) and Japan (6.11%) Germany, India and Australia ranks at 5^h to 7^h positions (their global publications share ranging from 3.56% to 5.71%). The countries that fall between 8^{th} and 12^{th} positions are Canada, Italy, France, Turkey and Spain with their global publications share ranging from 1.99% to 2.91%. Other countries, namely Brazil, Netherlands and Austria rank at 13^{th} to 15^{th} positions with their global publications share ranging from 1.29% to 1.99%. (Table 1).

The developed countries showing increase in their publications share are Turkey by 1.17, followed by Spain (1.08%), Canada (0.75%), Italy (0.47%), Netherlands (0.29%), Austria (0.24%), France (0.20%) and Australia (0.05%) from the year 2002 to the year 2011. In contrast, the developed countries showing decrease in their publications share during the same period are Japan by 2.25%, USA (1.68%), U.K. (1.54%) and Germany (0.68%). All developing countries among the top 20 countries, on the other hand, have shown rise in their publications share in cataract research: China by 9.02%, followed by India (2.03%) and Brazil (0.63%) from the year 2002 to the year 2011 (Table 1).

Table 1. Publications Output, Share and Rank of Top 15 Countries in Cataract Research, 2002-11

S.No	Country.	Number of Papers			Share of Papers			Total Citations	ACPP
		2002	2011	2002-11	2002	2011	2002-11	2002-11	2002-11
1.	USA	516	733	6514	25.48	23.80	24.08	56593	8.69
2.	U.K.	189	240	2612	9.33	7.79	9.66	20336	7.79
3.	China	54	360	2208	2.67	11.69	8.16	4678	2.12
4.	Japan	156	168	1652	7.70	5.45	6.11	6785	4.11
5.	Germany	119	160	1544	5.88	5.19	5.71	13106	8.49
6.	India	87	195	1293	4.30	6.33	4.78	4218	3.26
7.	Australia	70	108	964	3.46	3.51	3.56	7662	7.95
8.	Canada	44	90	786	2.17	2.92	2.91	6574	8.36
9.	Italy	51	92	753	2.52	2.99	2.78	7590	10.08
10.	France	46	76	736	2.27	2.47	2.72	6433	8.74
11.	Turkey	40	97	703	1.98	3.15	2.60	2357	3.35
12.	Spain	32	82	641	1.58	2.66	2.37	5429	8.47
13.	Brazil	28	62	538	1.38	2.01	1.99	2225	4.14
14.	Netherlands	33	59	408	1.63	1.92	1.51	3587	8.79
15.	Austria	22	41	349	1.09	1.33	1.29	2979	8.54
	World	2025	3080	27053	100.0	100.0	100.0	187682	6.94
ACPP=Average Citation Per Paper									

India ranks at 6th position among the top 15 most productive countries in cataract research with its global publications share of 4.78% during 2002-11. China and South Korea ranked at 3th and 13th positions, with global publications share of 8.16% and 1.99%, respectively during 2002-11. India's global publications share increased from 4.30% to 4.78% from the year 2002 to the year 2011. China and Brazil's global publications share increased from 2.67% to 8.16% and 1.38% to 1.99% from the year 2002 to the year 2011 (Table 1).

Considering the quality of papers published by these productive countries in terms of average citation per paper, which varies from 2.12 to 10.08 during 2002-11. The highest citation impact is registered by Italy with 10.08 citations per paper, followed by Netherlands (8.79), France (8.74), USA (8.69), Austria (8.54), Germany (8.49), Spain (8.47), Canada (8.36), Australia (7.95), U.K. (7.79), Brazil (4.14), Japan (4.11), Turkey (3.35), India (3.26) and China (2.12) (Table 1)

Publications Output in Cataract Research

The world's cumulative publication output in cataract research consisted of 27053 papers during 2002-11, with an average number of 2705.3 papers per year and an annual average growth rate of 4.89%. The cumulative world publications output in cataract research increased from 12239 papers during 2002-06 to 14814 papers during 2007-11, witnessing a growth of 21.04%. In terms of impact and citation quality, the average citation per paper registered by world publication output in cataract was 6.94 during 2002-11. The

average citation per paper of cumulative world publications in cataract research has decreased from 7.82 during 2002-06 to 5.21 during 2007-11 (Table 2A and Table 2B).

Table 2A. Growth of World Conjunctivitis Research, 2002-11

Period	TP
2002	2025
2003	2166
2004	2485
2005	2777
2006	2786
2007	2890
2008	2849
2009	2975
2010	3020
2011	3080
2007-11	27053

Table 2B. Research Output and Citation Quality of World Cataract Research, 20002-11

Period	TP	TC	ACPP
2001-06	12239	95709	7.82
2007-11	14814	77181	5.21
2007-11	27053	187682	6.94

Types of Cataract Research

Under different type of cataract research (classified by etiology), the maximum world publication output (7862) during 2002-11 was on cataract associated with primary ocular diseases with 29.06% publication share, followed by congenial cataract (4524 papers, 16.72% share), cataract associated with environmental exposure (3676 papers, 13.59% share), cataract associated with metabolic disorders (2708 papers, 10.01% share), age related cataract (2614 papers, 9.66% share), traumatic cataract (604 papers, 2.23% share), cataract associated with renal disease (374 papers, 1.38% share), cataract associated with central nervous system (338 papers, 1.25% share), cataract associated with connective tissue or skelton disorders (196 papers, 0.72% share), cataract associated with cutaneous disease (163 papers, 0.60% share) and cataract associated with Down's syndrome (7 papers, 0.03% share). In terms of citation impact, the maximum (8.05) was achieved by cataract associated with renal disease, followed by age related cataract (7.16), cataract associated with metabolic disorders (7.12), cataract associated with connective tissue or skelton disorders (6.82), cataract associated with central nervous system (6.49), cataract associated with environmental exposure (6.46), cataract associated with cutaneous disease (5.37), congenial cataract (4.97), cataract associated with primary ocular diseases (4.80), traumatic cataract (4.53) and cataract associated with Down's syndrone (4.00)(Table 3)

Table 3. World Publication Output & Citation Quality in Different Types of Cataract Research, 2002-11

Cataract by Etiology	TP	TC	ACPP	%TP
Age Related Cataract	2614	18714	7.16	9.66
Congenital Cataract	4524	22497	4.97	16.72
Traumatic Cataract	604	2738	4.53	2.23
Cataract associated with Environmental Exposure	3676	23750	6.46	13.59
Cataract associated with Primary Ocular Diseases	7862	37724	4.80	29.06
Cataract associated with Systematic Diseases				
Cataract associated with Metabolic Disorders	2708	19287	7.12	10.01
Cataract associated with Renal Disease	374	3009	8.05	1.38
Cataract associated with Central Nervous System	338	2195	6.49	1.25
Cataract associated with Connective Tissue or Skelton Disorders	196	1336	6.82	0.72
Cataract associated with Cutaneous Disease	163	876	5.37	0.60
Cataract associated with Down's Syndrone	7	28	4.00	0.03
	27053			
TP=Total Papers; TC=Total Citations; ACPP=Average Citation Per Paper				

Relatedness of various Diseases to Cataract Research as reflected through Co-occurences

This section investigates the relatedness of various diseases to world cataract literature through co-word analysis during 2002-11. Some specific diseases play an important role in the development of cataract. It was found that cataract keywords have comparatively: (i) higher frequency of co-occurrences with glaucoma or glaukomflecken (5160 papers), diabetes mellitus (1743 papers), retinal detachment (1742 papers), cornea (1376) and uveitis (1225 papers); (ii) medium frequency of co-occurrence with myopia (1041 papers) and retinal degeneration (790 papers) and (iii) low frequency of co-occurrence with intraocular tumor (262 papers), aniridia (148 papers), myotonic dystrophy (124 papers), microphthalmos (119 papers), retinopathy of prematurity (116 papers), hypoparathyroidism or hypocalcemia (111 papers), galactosemia (79 papers), persistent hyperplastic primary vitreous (66 papers), Peter's anomaly (40 papers), Werner's syndromes (24 papers), anterior segment necrosis (14 papers), congenital ectodermal dysplasia (13 papers), Marfan's syndromes (12 papers), sclerocornea (11 papers), Wilson's disease (7 papers), Down's syndromes (7 papers), neurofibromatosis (6 papers), Lowe's syndrome (5 papers), retinal anoxia (3 papers)

World Cataract Research Output in Context of Different Subjects

World's publication output in cataract research during 2002-11 has been published in context of 5 subjects (as reflected in database classification based on journal subject content), with highest publications output coming from medicine (23974 papers and 88.62% publications share), followed by neurosciences (3222 papers and 11.91% publications share), biochemistry, genetics & molecular biology (2061 papers and 7.62% publications share), pharmacology, toxicology & pharmaceutics (1228 papers and 4.54% publications share) and health profession (463 papers and 1.71% publications share). On analyzing the

quality and citation impact of cataract research under different subjects, it was found that biochemistry, genetics & molecular biology had scored the highest impact (9.48 citations per paper), followed by pharmacology, toxicology & pharmaceutics (5.11 citations per paper), medicine (4.80 citations per paper), neurosciences (4.07) and health profession (2.70 citations per paper)(Table 4)

Table 4. Subject-Wise Break-up of World Publications in Cataract Research during 2002-11

Subfields	TP	TC	ACPP	% TP
Medicine	23974	115075	4.80	88.62
Neurosciences	3222	13101	4.07	11.91
Biochemistry, Genetics & Molecular Biology	2061	19535	9.48	7.62
Pharmacology, Toxicology & Pharmaceutics	1228	6272	5.11	4.54
Health Profession	463	1252	2.70	1.71
Total*	27053			100.00
TP=Total Papers; TC=Total Citations; ACPP=Average Citations per Paper				
*Total of India in cataract research. There is some overlapping of literature under different sub-fields. As a result, the combined output of world under 5 sub-fields will be more than its total research output				

Cataract Research by Different Age Group of Population

The maximum focus of cataract research in terms of research output during 2002-11 was on adults (9038 papers and 33.41% share), followed by middle aged (6634 papers and 24.52% share), aged 80 & over (3500 papers and 12.94% share), child (2598 papers and 9.60% share) and adolescents (2262 papers and 8.36% share). The focus of cataract research has increased in middle aged (from 17.27% to 30.42%) and child (from 8.95% to 10.14%) from 2002-06 to 2007-11, as against decrease in adults (from 34.95% to 32.16%), aged 80 & over (from 13.65% to 12.36%) and adolescents (from 8.73% to 8.06%) during the similar period (Table 5).

Table 5. Cataract Research Output by Different Age Group of Population

Population by Age Group	**Number of Papers**			**Percentage of Papers**		
	2002-06	**2007-11**	**2002-11**	**2002-06**	**2007-11**	**2002-11**
Adults	4242	4796	9038	34.95	32.16	33.41
Middle Aged	2097	4537	6634	17.27	30.42	24.52
Aged 80 & Over	1657	1843	3500	13.65	12.36	12.94
Child	1086	1512	2598	8.95	10.14	9.60
Adolescents	1060	1202	2262	8.73	8.06	8.36
Total	12139	14914	27053	100.00	100.00	100.00

Research Profile of Most Productive World Institutions in Cataract Research

The top 20 most productive world institutions involved in cataract research have published 116 or more papers each during 2002-11. The publication profiles of these 20 institutions along with their research output, citations received and h-index values are presented in Table 6. These 20 institutions account for

12.64% share (3419 papers) of the publications output of world with an average output per institution of 170.95. Four institutions have registered higher publications share than the group average. These are University College of London (UCL), Institute of Ophthalmology, London, UK with 436 papers during 2002-11, followed by University of Melbourne, Department of Ophthalmology, Melbourne, Australia (199 papers), Harvard Medical School, Massachusetts Eye and Ear Infirmary, Boston, USA (193 papers) and University of Sydney, Department of Ophthalmology, Sydney, Australia (183 papers). The average citation per paper registered by the total papers of these 20 institutions is 7.72 on a three year citation window. Nine institutions have registered comparative higher impact than the group average. The highest impact of 15.10 citations per paper was scored by the Harvard Medical School, Massachusetts Eye and Ear Infirmary, Boston, USA, followed by University of Sydney, Department of Ophthalmology, Sydney, Australia (13.18), University of Miami, Leonard M School of Medicine, Bascom Palmer Eye Institute, Miami, Florida, USA (11.37), The John Hopkins University, School of Medicine, Lions Vision Research & Rehabilitation Center, Baltimore, USA (11.10), University of California, San Francisco, USA (10.60), London School of Hygiene and Trophical Health, International Center for Eye Health, London, UK (9.14), Wills Eye Institute, Philadelphia, USA (9.11), Medical University of Vienna, Department of Ophthalmology & Optometry, Vienna, Austria (8.79) and Clevland Clinic Foundation, Cole Eye Institute, Clevland, Ohio, USA (8.52).

Measuring the performance of these institutions on the basis of h- index, eight institutions have achieved a higher h-index value than the group average of 25.75. These are University College of London (UCL), Institute of Ophthalmology, London, UK with h-index of 38, followed by University of Sydney, Department of Ophthalmology, Sydney, Australia and University of Heidelberg, Department of Ophthalmology, Mannheim, Germany (31 each), Harvard Medical School, Massachusetts Eye and Ear Infirmary, Boston, USA and National Eye Institute, National Institute of Health, Bethesda, USA (30 each), University of Melbourne, Department of Ophthalmology, Melbourne, Australia (29), The John Hopkins University, School of Medicine, Lions Vision Research & Rehabilitation Center, Baltimore, USA (28) and University of Miami, Leonard M School of Medicine, Bascom Palmer Eye Institute, Miami, Florida, USA (26) (Table 6).

Table 6. Productivity & Citation Impact of Top Twenty Major World Institutions in Cataract Research, 2002-11

S.No.	Name	TP	TC	ACPP	H-Index
1	University College of London (UCL), Institute of Ophthalmology, London, UK	436	3345	7.67	**38**
2	University of Melbourne, Department of Ophthalmology, Melbourne, Australia	199	1532	7.70	**29**
3	Harvard Medical School, Massachusetts Eye and Ear Infirmary, Boston, USA	193	2915	15.10	**30**
4	University of Sydney, Department of Ophthalmology, Sydney, Australia	183	2412	13.18	**31**
5	National Eye Institute, National Institute of Health, Bethesda, USA	165	1300	7.88	**30**

6	Medical University of Vienna, Department of Ophthalmology & Optometry, Vienna, Austria	163	1433	8.79	25
7	London School of Hygiene and Trophical Health, International Center for Eye Health, London, UK	167	1527	9.14	25
8	All India Medical Science, Dr Rajendra Prasad Center for Ophthalmologial Sciences, New Delhi, India	162	556	3.43	25
9	Wills Eye Institute, Philadelphia, USA	151	1376	9.11	23
10	Capital Medical University, Beijing Tongren Hospital, Beijing Tongren Eye Center, Beijing, China	148	497	3.36	15
11	University of Heidelberg, Department of Ophthalmology, Mannheim, Germany	150	673	4.49	**31**
12	L.V. Prasad Eye Institute, Hyderabad, India	144	502	3.49	18
13	Sun Yat-Sen University, Zhongshan Ophthalmic Center, Guangzhou, China	139	406	2.92	15
14	Federal University of Sao Paulo, Vision Institute, Sao Paulo, Brazil	139	648	4.66	17
15	University of California, San Francisco, USA	136	1442	10.60	27
16	Chinese University of Hong Kong, Department of Ophthalmology & Visual Science, Hong Kong, China	133	763	5.74	23
17	University of Toronto, Toronto, Canada	123	794	6.46	23
	Clevland Clinic Foundation, Cole Eye Institute, Clevland, Ohio, USA	124	1056	8.52	23
18	University of Miami, Leonard M School of Medicine, Bascom Palmer Eye Institute, Miami, Florida, USA	124	1410	11.37	**26**
19	The John Hopkins University, School of Medicine, Lions Vision Research & Rehabilitation Center, Baltimore, USA	124	1376	11.10	**28**
20	University of Sao Paulo, Department of Ophthalmology, Sao Paulo, Brazil	116	451	3.89	13
	Total	3419	26414	7.72	25.75
	Total of the World	27053			
	Share of Top 15 Institutions in World Output	12.64			
TP =Total Papers; TC = Total Citations; ACPP = Average Citations Per Paper					

Contributions and Impact of Most Productive Authors in Cataract Research

Twenty authors have been identified as productive authors who have published 51 or more papers in cataract research. These 20 authors together contributed 1489 papers with an average of 74.45 papers per author and account for 5.5% of world publications output during 2002-11. Seven authors have published higher number of papers than the group average (74.45). These are: D.S.C. Lam with 127 papers, followed by A. R. Vasavada (110 papers), J.B. Jonas (98 papers), O. Findl (96 papers), N. Mamalis and P. Mitchell (92 papers each) and R. Menapace (88 papers). Considering the quality/impact of papers, these productive authors have received a total of 9976 citations for 1489 papers with an average of 6.70 citations per paper. Eight authors have registered higher impact than the average. These are: I.U. Scott with ACPP of 12.40,

followed by P. Mitchell (11.28), J.B. Jonas (11.13), S. Sacu (10.60), O. Findl (8.38), J.L. Alio (7.63), L. Werner (7.54) and R. Menapace (7.27). Measuring the performance of these authors on the basis of h-index, nine authors have achieved a higher h-index value than the group average of 17.30. These are P. Mitchell and J.B. Jonas with h-index of 24 each, followed by I.U. Scott and O. Findl (23 each), R. Menapace (22), L. Werner (20), S. Sacu and N. Mamlis (19 each) and J.L. Alio (18) (Table 7)

Table 7. Productivity & Citation Impact of World's Top Twenty Authors in Cataract Research, 2002-11

S.No	Name	Address	TP	TC	ACPP	H-Index
1	D.S.C. Lam	Chinese University of Hong Kong, Department of Ophthalmology & Visual Science, Hong Kong, China	127	472	3.72	16
2	A. R. Vasavada	Iladevi Cataract Intraocular Lens Research, Ahmedabad	110	395	3.59	16
3	J.B. Jonas	Ruprecht-Karls-University of Heidelberg, Medical Faculty Mannheim, Germany	98	1091	11.13	24
4	O. Findl	VIROS-Vienna Institute fur Research in Ocular Surgery, Austria	96	804	8.38	23
5	N. Mamalis	University of Utah, John A Moran Eye Center, Salt Lake City, UT, USA	92	596	6.48	19
6	P. Mitchell	University of Sydney, Department of Ophthalmology, Sydney, Australia	92	1038	11.28	24
7	R. Menapace	Medical University of Vienna, Department of Ophthalmology & Optometry, Vienna, Austria	88	640	7.27	22
8	T. Kohnen	Goethe-University, Department of Ophthalmology, Frankfurt am Main, Germany	72	516	7.17	15
9	R.H. Trivedi	Medical University of South Carolina, Storm Eye Institute, Charleston, USA	71	323	4.55	15
10	K.Yao	Zhejiang University, School of Medicine, Hangzhou, China	70	203	2.90	11
11	L. Werner	University of Utah, John A Moran Eye Center, Salt Lake City, UT, USA	65	490	7.54	20
12	J.L. Alio	Universidad Miguel Hernandez, Division of Ophthalmology, Alicante, Spain	65	496	7.63	18
13	S. Masket	University of California, David Geffen School of Medicine, Department of Ophthalmology, Los Angles, USA	61	297	4.87	12
14	M.E. Wilson	Medical University of South Carolina, Storm Eye Institute, Charleston, USA	61	273	4.48	15
15	I.U. Scott	Pen State College of Medicine, Department of Ophthalmology & Public Health, Hershey, PA, USA	57	707	12.40	23
16	S. Sacu	Medical University of Vienna, Department of Ophthalmology, Vienna, Austria	57	604	10.60	19
18	H.B.Dick	Ruhr University Eye Clinic, Centre for Vision Science, Bochum, Germany	52	266	5.12	12
17	K. Hayashi	Saga University, Department of Ophthalmology, Saga, Japan	53	272	5.13	13

19	T. Oshika	University of Tsukuba, Institute of Clinical Medicine, Departmrent of Ophthalmology, Japan	51	214	4.20	15
20	P. Courtright	Good Samartan Foundation, Centre for Community Ophthalmology, Moshi, Tanzania	51	279	5.47	14
		Total	1489	9976	6.7	17.3
		Total of the Country	27053			
		Share of Top 15Authors in Country Output	5.5			
TP =Total Papers; TC = Total Citations; ACPP = Average Citations Per Paper						

Patterns of Research Communication

The 20 most productive journals publishing world research papers together contributed 10454 papers in cataract research, which accounts for 38.64% of the world total output during 2002-11. The cumulative publications share of these 20 most productive journals showed a increase in India's publications output from 38.36% during 2002-06 to 38.88% during 2007-11 (Table 8).

Table 8. World: Media of Communication in Cataract Research, 2002-11

S.No	Name of the Journal	Number of Papers		
		2002-06	2007-11	2002-11
1	Journal of Cataract and Refractive Surgery	1341	1299	2640
2	International Journal of Ophthalmology	145	737	882
3	Ophthalmology	360	422	782
4	Eye	312	419	731
5	British Journal of Ophthalmology	379	323	702
6	American Journal of Ophthalmology	343	284	627
7	Archives of Ophthalmology	189	211	400
8	Clinical & Experimental Ophthalmology	180	206	386
9	Japanese Journal of Clinical Ophthalmology	204	159	363
10	Investigative Ophthalmology & Visual Science	170	192	362
11	Molecular Vision	89	227	316
12	European Journal of Ophthalmology	115	195	310
13	Graefe S Archive for Clinical and Experimental Ophthalmology	135	154	289
14	Retina	99	171	270
15	Kinische Monatsblatter Fur Augenheikunde	120	129	249
16	Chinese Ophthalmic Research	119	121	240

17	Canadian Journal of Ophthalmology	60	176	236
18	Current Opinion in Ophthalmology	92	134	226
19	Experimental Eye Research	123	97	220
20	Cornea	81	142	223
	Total	4656	5798	10454
	Total of the World	12139	14914	27053
	Share of top 20 journals in world total output	38.36	38.88	38.64

Summary

The world has published 27053 papers in cataract research during 2002-11, which has increased from 2025 papers in 2002 to 3080 papers in 2011, witnessing an annual average growth rate of 4.89%. In terms of impact and citation quality, the average citation per paper registered by world publication output was 6.94 during 2002-11, which has decreased from 7.82 during 2002-06 to 5.21 during 2007-11. Among the top 15 most productive countries in cataract research during 2002-11, the United States tops the list, with a share of 24.08% during 2002-11, followed by U.K. (9.66% share), China (8.16% share), Japan (6.11% share), Germany (5.71% share), etc. Among developing countries, China, India and Brazil are ranked at 3rd, 6th and 13th positions, with a global publication share of 8.16%, 4.78% and 1.99%, respectively during 2002-11. The global share of China has increased from 2.67% to 11.69%, India from 4.30% to 6.33% and Brazil from 1.38% to 2.01% from the year 2002 to the year 2011. Among the top 15 most productive countries, the largest (8.798) citation impact was made by Netherlands, followed by France (8.74), USA (8.69), Austria (8.54), Germany (8.49), Spain (8.47), Canada (8.36), Australia (7.95), U.K. (7.79), etc. Among developing countries, Brazil, India and China are ranked at 15th, 19th and 20th rank with citation impact of 4.14, 3.26 and 2.12.

Among different types of cataract research during 2002-11, the largest contribution (29.06% share) comes from cataract associated with primary ocular diseases, followed by congenial cataract (16.72% share), cataract associated with environmental exposure (13.59% share), cataract associated with metabolic disorders (10.01% share), age related cataract (9.66% share), traumatic cataract (2.23% share), cataract associated with renal disease (1.38% share), cataract associated with central nervous system (1.25% share), cataract associated with connective tissue or skelton disorders (0.72% share), cataract associated with cutaneous disease (0.60% share) and cataract associated with Down's syndrome (0.03% share). Among the subfield wise distribution of world cataract research during 2001-11, the largest contribution (88.62% share), comes from medicine, followed by neurosciences (11.91% share), biochemistry, genetics & molecular biology (7.62% share), pharmacology, toxicology & pharmaceutics (4.54% share) and health profession (1.71% share). The largest focus of cataract research during 2002-11 was on adults (with 33.41% share), followed by middle aged (24.52% share), aged 80 & over (12.94% share), child (9.60% share) and adolescents (8.36% share).

The top 15 most productive world institutions involved in cataract research have together contributed 12.649% share (3419 papers) in the cumulative world publications output, with an average of 170.95 papers per institution. The average citation per paper and h-index registered by the total papers of these 15 institutions was 7.72 and 25.75 during 2002-11.The 15 most productive authors together contributed 5.50% share (1489 papers) in the cumulative world's publications output during 2002-2011, with an average of 74.45 papers per author. The average citation per paper and h-index registered by the total papers of these 15 authors was 6.70 and 17.30 during 2002-11. The 20 most productive journals publishing world research papers in cataract research together accounts for 38.64% share of the total world output during 2002-11, which increased from 38.36% during 2002-06 to 38.88% during 2007-11

Cataract is a significant and increasing global problem. The challenges are to prevent or delay cataract formation and cure that which occurs. Common prevention methods include regular eye examination, life style and diet changes (wearing sunglasses and hat to block ultraviolet sunlight and quitting smoking) and eating (green and leafy vegetables and fruits and other foods rich in antioxidants). In addition, preventive interventions must be identified, perfected and delivered through research changes in government policy and legislation and modification of community and individual behavior. Widespread surgical services capable of delivering good vision rehabilitation must be acceptable and accessible to all in need, no matter what their circumstances. To establish and sustain these services requires comprehensive strategies. There must be changes in government priorities, population education and where missing, an integrated approach to surgical and management training, with supply start up capital equipment and help in setting up of surgical unit, consumables re-supply and cost recovery mechanisms.

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