



21st century bibliometric analysis of the field of dry eye disease

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VIEWPOINT

21st century bibliometric analysis of the field of dry eye disease

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Introduction

In 2012, the lead author of this paper (JJN) conducted a citation analysis of dry eye research to identify the leading papers, authors, institutions, countries and journals in the field.¹ That analysis was essentially an historical overview of publications on this topic extending back over the past century. Because a strong and growing foundation of scientific literature is a fundamental component of evidenced-based clinical care of patients, the current work was conducted to update the research community on trends in the 21st century dry eye literature, and to compare this new literature with the prior analysis in the context of events or trends in the dry eye field.

Search strategy

The search protocol used here was undertaken using the Scopus database (Elsevier) on December 30, 2020 and was restricted to all document types published in journals in English between 2001 and 2021. The following search term was derived to ensure (a) high sensitivity, including a wide capture of articles with “dry eye” as the primary theme, and (b) high specificity, so as to rule out irrelevant or peripherally related articles:

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TITLE({dry eye} OR {dry-eye} OR {dry eyes} OR {tear physiology} OR {tear fluid} OR {TFOS} OR {DEWS} OR {meibum} OR {meibomian} OR {blepharitis} OR {ocular surface disease} OR {ocular surface} OR {tear film} OR {tear-film} OR (keratoconjunctivitis AND sicca) OR {dysfunctional tear syndrome} OR {tear-fluid} OR {punctal plug} OR (lacrimal) OR {tear cytokine} OR (ocular W/10 symptom*) OR {ocular mucin} OR (biochemistry W/10 tears) OR (sjogrens W/20 ocular) OR (Sjogren W/20 tears) OR (cyclosporine W/10 ophthalmic) OR (mcmonnie*) OR (p2y2 W/20 ocular)) AND (PUBYEAR > 2000) AND (LIMIT-TO(SRCTYPE, "j")) AND (LIMIT-TO(LANGUAGE, "English"))
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The search revealed 10,178 dry eye-related papers, from which the top 25 most cited papers could be determined by simple sorting within Scopus. A subject-specific h-index for ‘dry eye’ (the “h_{DE}-index”) was derived, to serve as a measure of the *impact* of authors, institutions, countries and journals in the field of dry eye research. The detailed methodology for determining the subject-specific-index and identifying the top-ranked entities in each of these categories is the same as that employed by Efron et al² and will not be repeated here.

In considering these data, it is important to note that the different categories are not necessarily mutually exclusive (i.e. the most prominent papers, authors, countries and institutions are likely to be somewhat associated).

Highly cited papers

As shown in Figure 1, the volume of dry eye literature has rapidly increased during the 21st century such that approximately 1,150 papers will be published in 2020 (compared with an average of 444 papers per year over the 20 year span). The h_{DE} -index for all 10,178 articles in this field is 151, attracting 196,364 citations; 18.1% of these articles have never been cited.

The 25 most highly cited papers are listed in Table 1 of the Supplementary Material. While the topics are broad, nine of the top 25 articles relate to international workshops in meibomian gland dysfunction and dry eye disease; seven relate to tests, symptoms and outcomes; and seven relate to the prevalence of the disease.

Most impactful authors

Table 2 of the Supplementary Material lists the 25 most impactful authors of the 21st century, ranked by h_{DE} -index, along with the total count of dry eye-related papers published. The most impactful authors have individually published between 29 and 275 papers specifically related to dry eye between 2001-2021, and have h_{DE} -indices ranging from 24 to 56.

Kazuo Tsubota is the top-ranked author with a h_{DE} -index of 56 (he was also ranked #1 in 2012¹), with the next author separated by seven h_{DE} -index points. Dr Tsubota is also the most prolific author by a wide margin; he has published 275 dry eye-related papers, which is more than double the output #2-ranked Murat Dogru (134 papers). Of the top 25 authors, the majority are ophthalmologists, and three are optometrists— Kelly Nichols (rank #5), Jason Nichols (#11), and Alan Tomlinson (#22).

Leading institutions

The top 25 institutions from which papers emanated in the 21st century dry eye literature are listed in Table 3 of the Supplementary Materials, ranked by h_{DE} -index, along with the total paper count. Harvard University is the leading institution with a h_{DE} -index of 71; this university was also ranked #1 in the 2012 listing.¹ Institutions from the United States and Japan dominate the Top 10 list (12 institutions), with the University of New South Wales (rank #8) making an entry into the Top 10 in the current analysis.

Top countries

Table 4 of the Supplementary Material lists the top 25 countries, ranked by h_{DE} -index, along with the total paper count. The United States retains top ranking, with a h_{DE} -index of 123, followed by Japan, the United Kingdom, Australia and Spain. The top three remain the same as 2012,¹ while Australia is elevated in the rankings, rising from rank #8 to #4.

Prominent journals

The top 25 journals publishing dry eye-related articles in the 21st century are listed in Table 5 of the Supplementary Material, ranked by h_{DE} -index, as well as the total paper count. The top journal remains *Investigative Ophthalmology and Visual Science*, with an h_{DE} -index of 81; this journal also topped the rankings in 2012.¹ Fourteen of the 25 top-ranked journals are ophthalmology-based, having the word “ophthalmology” or “surgery” in the journal name (as well as the journal *Eye*, which is the official journal of the Royal College of Ophthalmologists in the United Kingdom)

Conclusions

The dry eye literature has shown considerable growth in the 21st century, with about 450 papers published each year in this field. Of the Top 25 papers published between 2001 and 2021, only two have been published since the 2012 bibliometric analysis¹ – both being part of the TFOS Dry Eye Workshop II (Table 1 of the Supplementary Material; papers ranked #5 and #15).³ Three of the Top 25 papers originated from the TFOS International Workshop on Meibomian Gland Dysfunction (Table 1 of the Supplementary Material; papers ranked #12, #13, and #20), which concluded in 2011.⁴

There has been a considerable rearrangement of the ranking of the Top 25 authors in the dry eye field, with many new entries on the list. Of the top 25 authors, Reza Dana was not ranked previously and is now ranked #7. Of those with a prior ranking, Kelly Nichols saw the greatest increase of 11 ranks, from #16 in 2012 to #5 in the current analysis.

The dry eye field has remained somewhat consistent in trends in top ranked countries and institutions, with some minor changes in these areas such as the greater prominence of Australia and Spain in dry eye research. There has been some variability in journal rankings. Although the top three journals have remained consistent, *The Ocular Surface* has risen in prominence from rank #19 to #4; this is probably because it was a newer journal in 2012 and the findings of the initial TFOS International Dry Eye Workshop, which were published in this journal, have been highly cited.

REFERENCES

- 1 Nichols JJ. Citation analysis of the dry eye literature. *Ocular Surface* 2013; 11: 35-46.
- 2 Efron N, Morgan P, Jones L et al. 21st century citation analysis of the field of contact lenses. *Clin Exp Optom* (in press).
- 3 Nelson JD, Craig JP, Akpek EK et al. TFOS DEWS II introduction. *The Ocular Surface* 2017; 15: 269-275.

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4 Nichols KK, Foulks GN, Bron AJ et al. The international workshop on meibomian gland dysfunction: Executive summary. Invest Ophthalmol Vis Sci 2011; 52: 1922-1929.

For Review

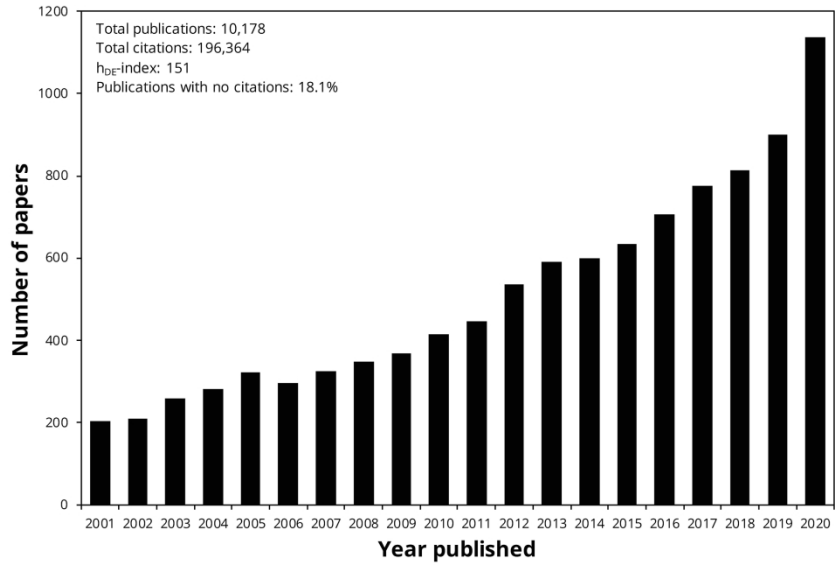
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[Figure caption]

Figure 1. Number of papers in the field of dry eye field published between 2001-2020.

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Supplementary Material

Table 1. Top 25 most cited dry eye-related articles published in the 21st century, ranked by author h_{DE}-index. Comparison with 2012 ranking provided. NR = not ranked. Note that several articles in the 2012 analysis are not included here as they were published before 2001 and outside the scope of the current search parameters.

Rank	Title	First Author	Journal	Year, Volume & Pages	Citations	2012 Rank
1	The definition and classification of dry eye disease: Report of the definition and classification subcommittee of the international dry eye workshop	Michael Lemp	The Ocular Surface	2007 5;75-92	1947	NR
2	Prevalence of dry eye syndrome among US women	Debra Schaumberg	American Journal of Ophthalmology	2003 136; 318-26	804	21
3	The epidemiology of dry eye disease: Report of the epidemiology subcommittee of the international Dry Eye Workshop	Janine Smith	The Ocular Surface	2007 5;93-107	749	NR
4	Grading of corneal and conjunctival staining in the context of other dry eye tests	Anthony Bron	Cornea	2003 22; 640-50	611	NR
5	TFOS DEWS II definition and classification	Jennifer Craig	The Ocular Surface	2017 15; 276-83	599	NR
6	Chitosan nanoparticles: A new vehicle for the improvement of the delivery of drugs to the ocular surface. Application to Cyclosporine A	Angela DeCampos	International Journal of Pharmaceuticals	2001 224; 159-68	548	NR
7	Methodologies to diagnose and monitor dry eye disease: Report of the diagnostic methodology subcommittee of the international Dry Eye Workshop	Anthony Bron	The Ocular Surface	2007 5;108-152	519	NR
8	Pro- and anti-inflammatory forms of interleukin-1 in the tear fluid and conjunctiva of patients with dry-eye disease	Abraham Solomon	Investigative Ophthalmology and Visual Science	2001 42; 2283-92	519	23
9	Functional aspects of the tear film lipid layer	Anthony Bron	Experimental Eye Research	2004 78; 347-60	499	NR
10	The lack of association between signs and symptoms in patients with dry eye disease	Kelly Nichols	Cornea	2004 23; 762-70	485	NR
11	The impact of dry eye syndrome on vision-related quality of life	Biljana Miljanovic	American Journal of Ophthalmology	2007 143; 409-15	481	NR
12	The international workshop on meibomian gland dysfunction: Report of the subcommittee on anatomy, physiology, and pathophysiology of the meibomian gland	Erik Knop	Investigative Ophthalmology and Visual Science	2011 52; 1938-78	447	NR

13	The international workshop on meibomian gland dysfunction: Executive summary	Kelly Nichols	Investigative Ophthalmology and Visual Science	2011 52; 1922-9	435	NR
14	Cultivated corneal epithelial stem cell transplantation in ocular surface disorders	Noriko Koizumi	Ophthalmology	2001 108;1569-74	413	NR
15	TFOS DEWS II epidemiology report	Fiona Stapleton	The Ocular Surface	2017 15;334-365	411	NR
16	Prevalence of ocular symptoms and signs with preserved and preservative free glaucoma medication	Pierre-Jean Pisella	British Journal of Ophthalmology	2002 86; 418-23	411	NR
17	Prevalence of dry eye among an elderly Chinese population in Taiwan: The Shihpai eye study	Pei-Yu Lin	Ophthalmology	2003 110; 1096-101	407	NR
18	Management and therapy of dry eye disease: Report of the management and therapy subcommittee of the international dry eye workshop	Steve Pflugfelder	The Ocular Surface	2007 5;163-178	402	NR
19	Experimental dry eye stimulates production of inflammatory cytokines and MMP-9 and activates MAPK signaling pathways on the ocular surface	Lihui Luo	Investigative Ophthalmology and Visual Science	2004 45; 4293-301	388	NR
20	The international workshop on meibomian gland dysfunction: Report of the definition and classification subcommittee	J Daniel Nelson	Investigative Ophthalmology and Visual Science	2011 52;1930-7	366	NR
21	Tear film osmolarity: Determination of a referent for dry eye diagnosis	Alan Tomlinson	Investigative Ophthalmology and Visual Science	2006 47; 4309-15	362	NR
22	Tear osmolarity in the diagnosis and management of dry eye disease	Michael Lemp	American Journal of Ophthalmology	2011 151; 792-8	361	NR
23	Prevalence of dry eye disease among US men: Estimates from the physicians' health studies	Debra Schaumberg	Archives of Ophthalmology	2009 127; 763-8	361	NR
24	Dysfunctional tear syndrome: A Delphi approach to treatment recommendations	Ashley Behrens	Cornea	2006 25; 900-7	359	24
25	Prevalence of ocular surface disease in glaucoma patients	Eamon Leung	Journal of Glaucoma	2008 17; 350-5	357	NR

Table 2. Top 25 authors of dry eye-related articles published in the 21st century, ranked by author h_{DE} -index. Comparison with 2012 ranking provided. NR = not ranked. Note that several authors in the 2012 analysis are not included here as the bulk of their publications occurred before 2001 and outside the scope of the current search parameters.

Rank	Author	h_{DE} -index	Paper count	2012 Rank
1	Kazuo Tsubota	56	275	1
2	Steve Pflugfelder	49	128	2
3	Murat Dogru	48	134	3
4	Shigeru Kinoshita	40	106	11
5	Kelly Nichols	40	80	16
6	Christophe Baudouin	38	119	7
7	Reza Dana	36	79	NR
8	Norihiko Yokoi	34	87	17
9	David Sullivan	34	77	4
10	Michael Stern	34	65	10
11	Jason Nichols	33	71	14
12	Gary Foulks	32	75	24
13	Cintia de Paiva	32	73	15
14	Jun Shimazaki	32	59	18
15	Yukihiro Matsumoto	31	52	8
16	Anat Galor	29	105	NR
17	Eiki Goto	28	44	9
18	Debra Schaumberg	27	35	NR
19	Louis Tong	25	99	NR
20	Margarete Cologne	25	42	NR
21	Takahiro Nakamura	25	39	NR
22	Alan Tomlinson	25	32	NR
23	Dequan Li	25	29	13
24	Gerd Geerling	24	60	NR
25	Miki Uchino	24	50	NR

Table 3. Top 25 institutions of dry eye-related articles published in the 21st century, ranked by institution h_{DE} -index. Comparison with 2012 ranking provided. NR = not ranked. Note that several institutions in the 2012 analysis are not included here as the bulk of their publications were published before 2001 and outside the scope of the current search parameters.

Rank	Institution	Country	H_{DE} -index	Paper count	2012 Rank
1	Harvard University ^a	United States	71	437	1
2	Keio University	Japan	60	295	2
3	Baylor College of Medicine ^b	United States	48	148	6
4	Tokyo Dental College	Japan	47	123	4
5	Kyoto Prefectural University of Medicine	Japan	44	154	16
6	University of Miami ^c	United States	42	201	8
7	Ohio State University	United States	40	109	5
8	University of New South Wales	Australia	39	157	14
9	Allergan	United States	38	101	13
10	UT Southwestern Medical Center/School	United States	35	76	NR
11	Quinze-Vingts National Ophthalmology Hospital	France	34	111	NR
12	University of Waterloo	Canada	33	104	20
13	National Singapore University ^d	Singapore	32	164	NR
14	University of Houston	United States	30	61	NR
15	Glasgow Caledonian University	United Kingdom	30	53	17
16	University of Louisville	United States	29	65	25
17	Johns Hopkins University ^e	United States	28	111	19
18	National Institute for Health and Medical Research	France	28	102	NR
19	Università degli Studi di Genova	Switzerland	28	55	NR
20	University of Oxford	United Kingdom	27	48	11
21	University of Southern California ^f	United States	26	131	3
22	Sorbonne University	France	26	86	NR
23	Fudan University ^g	China	25	94	NR
24	VA Medical Center	United States	25	80	NR
25	University of California, Berkeley	United States	25	70	NR

^aIncludes Harvard Medical School, Schepens Eye Research Institute, Brigham and Women's Hospital, and Massachusetts Eye and Ear Infirmary.

^bIncludes Cullen Eye Institute.

^cIncludes Bascom Palmer Eye Institute.

^dIncludes National University of Singapore, Faculty of Medicine, Singapore Eye Research Institute, Singapore National Eye Center, Duke-NUS Medical School Singapore, and Yong Loo Lin School of Medicine.

^eIncludes the Wilmer Eye Institute.

^fIncludes the Keck School of Medicine and School of Pharmacy.

^gIncludes Eye and ENT Hospital of Fudan University.

Table 4. Top 25 countries of dry eye-related articles published in the 21st century, ranked by country h_{DE} -index. Comparison with 2012 ranking provided. NR = not ranked. Note that several countries in the 2012 analysis are not included here as the bulk of their publications were published before 2001 and outside the scope of the current search parameters.

Rank	Country	h_{DE} -index	Paper count	2012 Rank
1	United States	123	3,140	1
2	Japan	81	967	2
3	United Kingdom	74	783	3
4	Australia	55	448	8
5	Germany	53	423	4
6	Spain	53	401	11
7	Italy	51	461	7
8	China	50	857	6
9	Canada	44	288	9
10	France	43	266	5
11	South Korea	42	536	14
12	Turkey	37	495	10
13	Singapore	37	186	NR
14	Brazil	32	222	13
15	India	31	618	12
16	Austria	24	91	18
17	Sweden	23	88	16
18	Netherlands	21	69	15
19	Denmark	21	61	19
20	Taiwan	19	139	NR
21	Poland	19	117	23
22	New Zealand	19	88	NR
23	Greece	19	72	24
24	Switzerland	19	64	20
25	Finland	19	57	22

Table 5. Top 25 journals of dry eye-related articles published in the 21st century, ranked by journal h_{DE} -index. Comparison with 2012 ranking provided. NR = not ranked. Note that several journals in the 2012 analysis are not included here as the bulk of their publications were published before 2001 and outside the scope of the current search parameters.

Rank	Journal	h_{DE} -index	Paper count	2012 Rank
1	Investigative Ophthalmology and Visual Science	81	599	1
2	Cornea	64	613	2
3	American Journal of Ophthalmology	59	235	4
4	The Ocular Surface	56	426	19
5	Ophthalmology	54	207	6
6	Experimental Eye Research	49	176	8
7	British Journal of Ophthalmology	46	224	5
8	Archives of Ophthalmology/JAMA Ophthalmology	40	130	7
9	Optometry and Vision Science	36	143	10
10	Current Eye Research	34	198	9
11	Eye and Contact Lens	30	199	NR
12	Eye	29	146	18
13	PLoS ONE	28	147	NR
14	Molecular Vision	27	62	24
15	Clinical Ophthalmology	25	213	NR
16	Contact Lens and Anterior Eye	25	158	NR
17	Graefe's Archive for Clinical and Experimental Ophthalmology	25	100	14
18	Ophthalmic Plastic and Reconstructive Surgery	24	285	13
19	Journal of Ocular Pharmacology and Therapeutics	24	105	NR
20	Journal of Cataract and Refractive Surgery	23	45	23
21	European Journal of Ophthalmology	21	108	25
22	Acta Ophthalmologica	21	91	22
23	Clinical and Experimental Ophthalmology	20	89	NR
24	Japanese Journal of Ophthalmology	20	62	NR
25	Ophthalmic Research	17	52	NR