ORIGINAL ARTICLE

Publication analysis of the contact lens field: What are the current topics of interest?

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Abstract

Purpose: To determine the main current research interests of scientists working in the contact lens field.

Methods: All articles published in the 2011 issues of all journals included in the Journal Citation Reports subject category *Ophthalmology* were inspected to expose those papers related to the contact lens field. Information regarding source journal was obtained and authorship details were recorded to determine the top most prolific authors, institutions and countries. A comprehensive list of key words was compiled to generate a two-dimensional term map in which the frequency of occurrence of a particular term is defined by label size and the distance between two terms is an indication of the relatedness of these terms, based on their co-occurrences within groups of key words. Clusters of related terms were also identified.

Results: Visual examination of all articles uncovered a total of 156 papers, published in 28 different journals. *Contact Lens & Anterior Eye, Eye & Contact Lens* and *Optometry and Vision Science* had 27 articles each. The most prolific authors and institutions revealed the predominance of countries with long research tradition in the contact lens field. Ten different word clusters or areas of interest were identified, including both traditional, yet unresolved issues (*e.g.*, comfort or dry eye), and the latest research efforts (*e.g.*, myopia control).

Conclusions: These findings, which revealed contact lenses to be a fertile area of research, may be of relevance to new researchers as well as to those interested in exploring the latest research trends in this scientific discipline.

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Análisis de publicaciones en el campo de las lentes de contacto: ¿cuáles son las cuestiones de interés actuales?

Resumen

Objetivo: Determinar los principales intereses actuales de los científicos que trabajan en el campo de las lentes de contacto.

Métodos: Se revisaron todos los artículos publicados en 2011 en las ediciones de todas las publicaciones incluidas en Journal Citation Reports, en la categoría de *Oftalmología*, en relación a las lentes de contacto. Se obtuvo información relativa a la fuente de la publicación, y se registraron datos sobre la autoría, para determinar los principales autores, instituciones y países más prolíficos. Se compiló una amplia lista de palabras clave para generar un mapa terminológico bidimensional en el que la frecuencia de ocurrencia de un término particular se definía mediante el tamaño de la etiqueta, siendo la distancia entre dos términos un indicador del parentesco de dichos términos, basado en las co-ocurrencias entre grupos de palabras clave. También se identificaron grupos de términos relacionados.

Resultados: El examen visual de todos los artículos descubrió un total de 156 documentos, publicados en 28 publicaciones diferentes. *Contact Lens & Anterior Eye*, *Eye & Contact Lens* y *Optometry and Vision Science* incluyeron 27 artículos cada una. Los autores e instituciones más prolíficos revelaron la predominancia de países con amplia tradición investigadora en el campo de las lentes de contacto. Se identificaron diez diferentes grupos o áreas de interés mundiales, incluyendo cuestiones tanto tradicionales, aunque aún sin resolver (por ejemplo, confort u ojo seco), como los últimos esfuerzos investigadores (por ejemplo, control de la miopía).

Conclusiones: Estos hallazgos, que revelaron que las lentes de contacto eran un área fértil de investigación, pueden resultar pertinentes para los nuevos investigadores, así como para aquellas personas interesadas en explorar las últimas tendencias investigadoras en esta disciplina científica.

1. Introduction

Scientists and clinicians devoting their research efforts to the contact lens field witnessed with interest and acclamation the recent incorporation to the Institute for Scientific Information (ISI) Journal Citation Reports (JCR) of two of the most influential publications in this field: *Eye & Contact Lens* (in 2010) and *Contact Lens & Anterior Eye* (in 2011). The Science Edition of the JCR lists about 5000 journals according to their impact factor, which is defined as ''the average number of times articles from the journal published in the past 2 years have been cited in the current JCR year'',[1,2] and classifies them in subject or thematic categories. Both contact lens journals are included in the *Ophthalmology* category, which also lists publications dedicated to ophthalmology, vision science and optometry.

In a seminal paper by Efron, Brennan and Nichols published in January 2012 the authors performed a complete citation analysis of the contact lens field, from the first article by Adolf Fick, dating from 1888 to February 2011.[3] Efron and co-workers examined all subject categories of the ''Science Citation Index Expanded'' database by following a search strategy consisting of providing the search engine of the Web of Science (Thomson Reuters, New York, NY) with a list of commonly employed terms in the contact lens field. After further refining their research, a total of 3096 articles were compiled, whereupon the most highly cited, influential papers were identified and the leading authors, source journals, institutions and countries associated with those articles were acknowledged.

Citation analysis is a useful approach for assessing the quality of research in a given field, based on the assumption that influential articles are more frequently cited by other researchers and clinicians. As such, abundant citation analysis literature exists, either examining the *Ophthalmology* subject category in general,[4–6] or a particularly relevant subspecialty (such as dry eye).[7,8] However, *per definition*, citation analysis uncovers the most highly cited articles of a given time period. Therefore, it may not be the best approach to determine the current topics of interest of a scientific discipline, with potentially high impact recent articles requiring several years to show a clear trend regarding their citation count.[8] This effect was evident upon exploring the 10 most highly cited articles in the contact lens field (ranked by citation count), with the most recent paper dating from 1999 (although an analysis by citation frequency, that is, cites per year, unveiled more recent research contributions).[3] In addition, it has been documented that, in general, basic and diagnostic research areas have an above average citation impact, in detriment of clinical research,[9] which may result in unwanted bias if citation analysis is employed to review current research trends.

The aim of the present study was to determine the current topics of research interest in the contact lens field. For this purpose, all articles published in the 2011 issues of all journals included in the JCR subject category *Ophthalmology* were visually inspected in order to expose those papers

related to the contact lens field, whereupon a comprehensive list of key words was compiled for further evaluation. In addition, information regarding source title (journal name) and language of the article was obtained to identify the main target journals for contact lens researchers and clinicians. Finally, authorship details (name of the authors, institutions and country of origin) were also recorded and analyzed to determine the top most prolific authors, institutions and countries in the contact lens field in 2011.

2. Methods

A single experienced optometrist (J.S.) accessed the Thompson Reuters Web of Science database in March 2013 to compile all journals listed in the subject category *Ophthalmology* in the latest edition of the JCR (2011, published in June 2012). A total of 58 journals were classified under this subject category. The same database was employed to recover information regarding editorial details (name of publisher, country of publisher, language or languages of published articles, issues per year and number of articles published in 2011), as well as 2-year impact factor and rank among the journals of the same subject category (when ordered by impact factor).

The same optometrist then successively visited the online editions of all the *Ophthalmology* journals and conducted a visual examination of all articles published in 2011 to determine those papers related to the contact lens field. Articles were investigated by title, abstract and, when available, list of key words. When in doubt, the full article was accessed and downloaded for careful examination. Only original articles, reviews and case reports published in 2011, irrespective of their publication-ahead-of-print date, were included in the analysis.

This process uncovered a total of 156 articles, published in 28 different journals. The full version of these articles was downloaded and the following information was recovered: title of the article, journal name, language or languages of the article, list of authors (only the first three authors were included, as this value was considered the median number of authors per paper), institution and country of first author (or corresponding author, if different) and key words provided by the authors (up to five key words per article were recorded and considered a ''group of key words'').

Key words were first submitted to a detailed visual inspection aimed at, on the one hand, converting all plural terms into singular ones (for example, from ''contact lenses'' to ''contact lens'') and, on the other hand, building a thesaurus file with which to merge different synonyms into a single term (for example, ''rigid gas permeable'', ''gas permeable'', ''RGP'', *etc.*). Following this step, a text file (corpus file) was generated by introducing key words into a simple text editor (Notepad for Windows) so that each line of text included all key words of a single article (group of key words). This corpus file was then imported into VOSviewer version 1.5.4 (©2013 Center for Science and Technology Studies, Leiden University, The Netherlands; freely available at: http://www.vosviewer.com/) for Windows.[10]

VOSviewer allows the creation of term maps. A term map is a two-dimensional map in which the frequency of occurrence of a particular term is defined by label size and the distance between two terms can be interpreted as an indication of the relatedness of these terms, based on the number of co-occurrences of terms in the corpus file. For example, in the present analysis it was expected that, overall, the term ''contact lens'' would be found in a significant number of groups of key words and that the term ''myopia'' would be less common, and also that in many particular groups of key words both the terms ''contact lens'' and ''myopia'' would occur together. Accordingly, VOSviewer allocated a high frequency label size to the term ''contact lens'' and a less frequent label size to the term ''myopia'', and placed both terms a short distance from one another on the term map. The thesaurus file was formatted and imported according to the instructions provided in the VOSviewer manual and used to prevent unwanted term duplicities during the creation of the term map. In addition, VOSviewer also provides a list of word clusters, that is, sets of words that may be considered as highly related to one another, and identifies them with the same set color in the term map.

3. Results

Table 1 displays the top journals with more than four published articles related to contact lenses. Information is provided regarding name and country of publisher, language or languages of published articles, issues per year, number of articles published in 2011, number and percentage of contact lens related articles and 2-year impact factor and rank amongst the journals listed under the *Ophthalmology* subject category. It is interesting to note that, whereas in total number of contact lens related articles, *Contact Lens & Anterior Eye*, *Eye & Contact Lens* and *Optometry and Vision Science* are tied at the first rank, with 27 articles each, this position is occupied by *Contact Lens & Anterior Eye* alone when examining the ratio of contact lens related articles over total number of articles (54%).

Authors with more than three articles in the contact lens field in 2011 are summarized in Table 2, together with their institution and country of origin. It may be noted that five out of the seven articles of the most prolific author, Professor Philip Morgan, from the Faculty of Life Sciences at the University of Manchester, England, are in shared authorship with the second most prolific author, Professor Nathan Efron, from the Institute of Health & Biomedical Innovation, School of Optometry and Vision Sciences, Queensland University of Technology. These articles, mainly published in *Contact Lens & Anterior Eye*, describe diverse surveys aiming at exploring regional and/or international contact lens prescription trends and compliance attitudes.

Institutions and countries with more than three articles are displayed in Tables 3 and 4, respectively. The Brien Holden Vision Institute, located in Australia, was identified as the most prolific institution, with a total of 13 articles published in 2011. In a number of articles, the joint contribution of USA, Australia and England and Wales (78 papers) was found equal to that of all the other publishing countries together.

All articles were written entirely in English, with the exception of two papers in German and another six in which a copy of the abstract was also available in a language

Table 1 Journals with more than four articles in the contact lens field, with indication of name and country of publisher, language, issues per year (i/y), number of articles published in 2011 (n), number (nCL) and percentage (%CL) of contact lens related articles and 2-year impact factor (IF) and rank in the *Ophthalmology* subject category (JCR 2011 edition).

Journal	Publisher	Country	Language	i/y	n	nCL	%CL	IF
Contact Lens & Anterior Eye	Elsevier Science Bv	Netherlands	English	6	50	27	54.0%	1.421 (33rd)
Eye & Contact Lens	Lippincott Williams & Wilkins	USA	English	6	68	27	39.7%	1.252 (35th)
Optom Vis Sci	Lippincott Williams & Wilkins	USA	English	12	181	27	14.9%	2.108 (20th)
Invest Ophthalmol Vis Sci	As Res Vision Ophthalmology Inc	USA	English	12	1198	22	1.8%	3.597 (6th)
Clin Exp Optom	Wiley-Blackwell	Australia	English	6	74	9	12.2%	1.047 (37th)
Cornea	Lippincott Williams & Wilkins	USA	English	12	295	9	3.1%	1.733 (25th)
Graefes Arch Clin Exp Ophthalmol	Springer	USA	English	12	229	5	2.2%	2.170 (19th)

Table 2 Authors with more than three articles in the contact lens field, with indication of number of articles (nCL), institution and country of origin.

Author	nCL	Institution	Country
Morgan P	7	Faculty of Life Sciences, University of Manchester[a]	England
Efron N	6	Institute of Health & Biomedical Innovation, School of Optometry and Vision Sciences, Queensland University of Technology	Australia
Zhu H	6	Brien Holden Vision Institute	Australia
Chalmers RL	5	Indiana University School of Optometry/Independent Consulting	USA
Willcox MDP	5	University of New South Wales	Australia
Jones L	4	School of Optometry and Vision Science, University of Waterloo[b]	Canada
Woods C	4	School of Optometry and Vision Science, University of Waterloo[b]	Canada
Wu YT	4	University of New South Wales	Australia
Young G	4	Visioncare Research Ltd., Farnham	England

[a] Includes: Eurolens Research.
[b] Includes: Center for Contact Lens Research.

Table 3 Institutions with more than three articles in the contact lens field, with indication of number of articles (nCL) and country of origin (*institution information refers to the address for correspondence offered by the corresponding author of each article*).

Institution	nCL	Country
Brien Holden Vision Institute	13	Australia
School of Optometry and Vision Science, University of Waterloo[a]	10	Canada
Faculty of Life Sciences, University of Manchester[b]	6	England
University of New South Wales	5	Australia
Visioncare Research Ltd., Farnham	4	England
Department of Vision Sciences, Glasgow-Caledonian University	4	Scotland
IOBA, Department of Physics TAO, University of Valladolid	4	Spain

[a] Includes: Centre for Contact Lens Research.
[b] Includes: Eurolens Research.

Table 4 Countries with more than three articles in the contact lens field, with indication of number of articles (nCL).

Country	nCL
USA	36
Australia	22
England and Wales	20
Canada	12
Spain	11
China	7
Japan	7
Netherlands	4

different than English (French, Chinese, German and Standard Hindi).

The term map resulting from key word analysis and created with VOSviewer is displayed in Fig. 1. Ten clearly defined word clusters were identified by VOSviewer based on the different degrees of relatedness of the terms. Table 5 displays all terms included in each word cluster, with indication (in bold) of the 12 most frequently used key words (with 6 or more occurrences), a list that was headed by the terms ''contact lens'' (61), ''silicone-hydrogel'' (15), ''compliance'' (11), ''keratitis'' (10) and ''soft contact lens'' (9). Overall, 55 key words with 3 or more occurrences were documented.

4. Discussion

The aim of the present study was to determine the current research interests of scientists and clinicians working in the contact lens field. Topics of interest were explored by examining the most frequently employed key words of all contact lens related articles published in 2011 in the journals listed under the subject category *Ophthalmology* of the JCR.

Citation analysis of a given discipline often follows a different approach. In effect, Efron and co-workers, in their analysis of citation in the contact lens field,[3] presented the Web of Science database search engine with a list of terms the authors considered to be representative of the contact lens field. In addition, the search was neither circumscribed to the *Ophthalmology* subject category, encompassing instead the whole ''Science Citation Index Expanded'', which includes about 5000 journals of diverse disciplines, nor to the latest edition of the JCR. This strategy resulted in the precise identification of the most highly cited articles of all time in the contact lens field, irrespective of the subject category under which their respective source title (journal) was classified, with many of the top ranked contributions originating from subject areas such as medicine or material sciences, that is, although it provided a detailed historical account of the contact lens publications up to the present date, current topics of interest were too recent to be accurately uncovered by citation analysis alone.

It was believed that, by providing a predefined list of terms to the search engine, a potential for bias was possible, given that the purpose of the present study was, precisely, to identify the main research interests of scientists and clinicians in the contact lens field, as determined by the list of key words offered by these authors in their manuscripts. Without a ''list of terms'' search strategy and against the practical impossibility to examine all articles published in all disciplines of science, only those originating in journals classified under the *Ophthalmology* subject category in 2011 were considered.

It must be noted that the present approach is only able to provide a one-year snap-shot of the field, which may be misleading, and that, without information on the future citation of the relevant articles, undue credit may be given to papers, or to prolific authors, which may not truly reflect important advancements in the field. As it has been documented that citations to articles published in a given year increase to a maximum between two and a six years after publication,[11] citation analysis of articles published in 2011 shall be the subject of a future study. The findings of that study should be able to determine the validity of the preliminary assumptions offered by the present data.

The present publication analysis revealed a total of 156 contact lens related articles, published in 28 different journals, with *Contact Lens & Anterior Eye*, *Eye & Contact Lens* and *Optometry and Vision Science* providing 27 articles each, although the first and second contact lens publishing journal ranks were awarded to *Contact Lens & Anterior Eye* and *Eye & Contact Lens*, respectively, when taking into consideration the ratio of contact lens related articles over total number of articles. Given the recent incorporation of these journals to the JCR list of impact journals under the subject category *Ophthalmology*, these findings suggest that contact lenses may already be treated as a new subcategory within the overall *Ophthalmology* thematic area, with clearly identifiable publishing journals.

It is interesting to note that, according to the 2011 JCR Science Edition database, the total number of articles published in 2011 in journals listed in the subject category of *Ophthalmology* was of 8319. Therefore, it may be observed that contact lenses constitute a very limited percentage (1.88%) of all papers published in the ophthalmic literature. Indeed, Efron and co-workers, in their citation analysis of the contact lens field,[3] uncovered a total of 3096 contact lens related articles published between 1888 (actually 1960) and 2010, with a yearly number of articles between 100 and 150 in recent years, in agreement with the present findings. As Efron and co-workers did not restrict their search to the Ophthalmology subject category, this agreement may be an indication that the number of contact lens related articles published outside this area may represent only a small fraction of the total of contact lens articles.

The analysis of the most prolific authors, institutions and countries did not expose unexpected findings. Indeed, a large portion of articles originated from authors from countries, such as USA, Canada, England and Australia, with long research tradition in the contact lens field, although it was also disclosed that authors from non-English speaking countries such as Spain, China or Japan are slowly gaining voice in this area of clinical research. These results, notwithstanding the differences in approach described above, are not in disagreement with the findings of Efron and co-workers.[3] It must be noted that no attempt was made to normalize country data by taking into account the *article per capita* ratio, as it was believed that a more
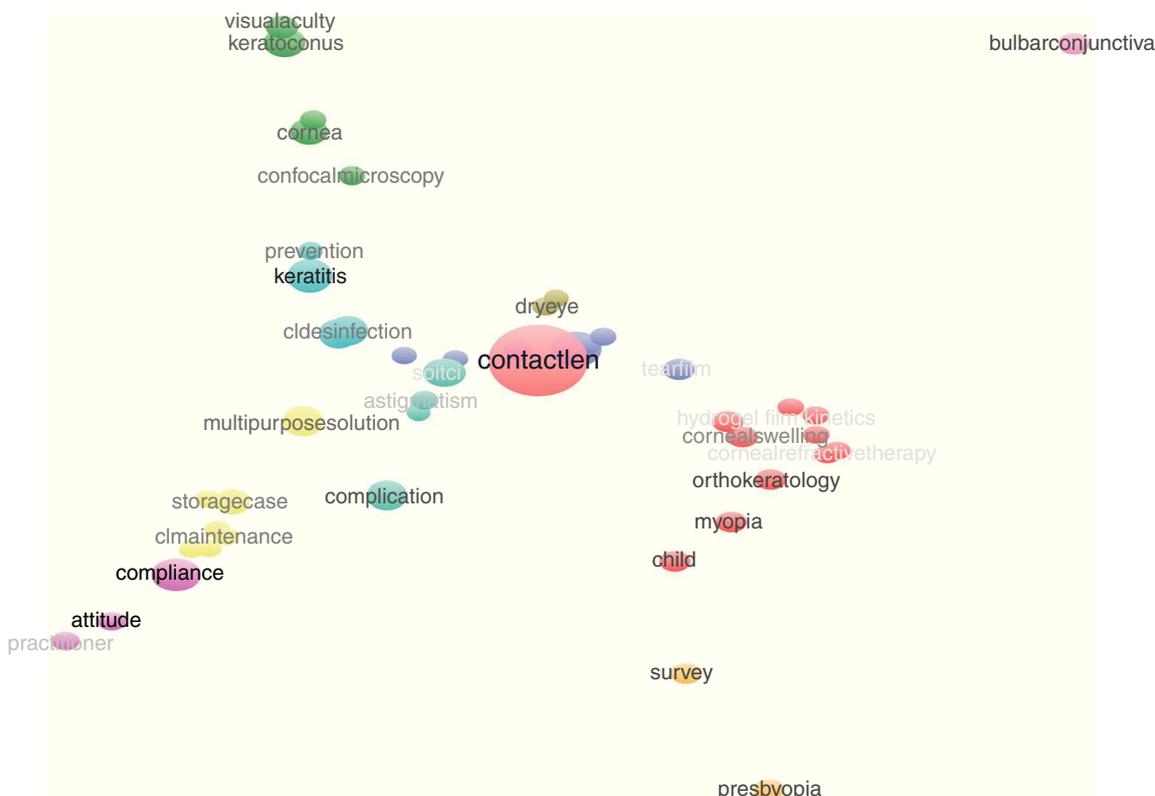
Figure 1 Term map generated with VOSviewer v.1.5.4. Size of labels is an indication of frequency of occurrence of each key word and different colors represent word clusters. In general, the shorter the distance between two terms, the closer their relation (higher number of co-occurrences in groups of key words) (*please note that some spelling liberties were required for VOSviewer to correctly manage key words*).

Table 5 Word clusters generated by VOSviewer to display sets of terms based on their degree of relatedness (terms in bold had 6 or more occurrences). Word cluster colors match those employed in Fig. 1.

	Word cluster	Proposed cluster subject category
1	Child; Comfort; **Contact lens**; Corneal refractive therapy; Corneal swelling; Hydrogel; Myopia; Orthokeratology; Tear film kinetics; Tear meniscus; Topography	Contact lens fitting in general, Orthokeratology, Myopia control, Comfort
2	Aberrations; Confocal microscopy; Contrast sensitivity; **Cornea**; **Keratoconus**; RGP; Ultraviolet; Visual acuity	Keratoconus and Vision
3	Adherence; Bandage contact lens; Candida; Deposit; Pseudomonas aeruginosa; **Silicone-hydrogel**; Tear film	Bacterial interaction with cornea and contact lens
4	Contact lens maintenance; Contact lens replacement; Hydrogen peroxide; Hygiene; **Multipurpose solution**; Osmolality; **Storage case**	Care and Maintenance
5	Attitude; Behavior modification; **Compliance**; Practitioner; Risk-taking	Compliance
6	Astigmatism; **Complication**; Prevalence; **Soft contact lens**	?
7	**Acanthamoeba**; **Contact lens disinfection**; **Keratitis**; Prevention	Keratitis
8	Presbyopia; Simultaneous vision; Survey; Vision evaluation	Presbyopia
9	Dry eye; Keratoconjunctivitis	Dry eye
10	Bulbar conjunctiva; Impression cytology	Conjunctiva

realistic approach would be to estimate other factors, including the number of licensed optometrists, research institutions, universities with an Optometry Department, *etc*. These considerations, however, were beyond the scope of the present study.

Key word analysis was able to identify 10 different word clusters, which may be interpreted as research interest areas. These included both traditional research topics such as keratitis, compliance, care and maintenance, dry eye or keratoconus and more recent research efforts, such as those devoted to myopia control or bacterial interaction with new contact lens materials, with the most prominent word cluster containing terms related to clinical approaches to contact lens fitting, tear film evaluation, orthokeratology and comfort. In addition, it may be observed that, besides new research interests and still unresolved issues, key word analysis disclosed the absence of some past predominant areas of research, most notably those related to oxygen transmissibility and corneal complications arising from hypoxia, a possible indication that these issues have been largely resolved and that research efforts have moved to other areas.

It must be noted that not all journals provide a list of key words for their articles. Most notorious amongst them is *Investigative Ophthalmology & Vision Science*, which published a total of 22 articles in the contact lens field in 2011. In these cases, the title of the paper was used as input in the corpus file, once articles, prepositions and other non-descriptive words were manually deleted. Interestingly, even though not all journals provide a list of visible key words on their published articles, during the online submission process authors are generally instructed to propose up to five key words, with which to describe the thematic content of their manuscript, either as an open list or by selecting terms from a predefined, and commonly journal specific, term compilation. These key words may be later used for editorial and manuscript management decisions such as choice of reviewers, topical editor or journal subsection/special issue or for future article classification in the appropriate databases.

The use of publication analysis to explore topics of interest has an intrinsic, obvious limitation: only published articles are entered into the analysis, that is, this approach may reflect not only the efforts of researchers but also the policies and preferences of the editorial boards and/or reviewers of the journals regarding manuscript acceptance. In addition, a large number of scientists, mainly working for the contact lens industry, may be under temporal non-disclosure agreements regarding their research. The inclusion of data from articles that did not reach publication may be able to provide a better, overall indication of the research being performed.[7] However, it must be observed that research impact and clinical impact may not necessarily reflect the same concept, as a particular article may be useful to guide clinical decisions even though it receives relatively few citations in the scholarly literature.[12]

All information regarding trending topics of research may be treated as a double-edged-sword. Thus, on one hand, it may encourage scientists to work in popular areas of research in which published articles are more susceptible to be cited by their peers, a factor that may also influence the editorial decisions of those journals aiming at improving their impact factor.[13] On the other hand, more obscure, risky, albeit sometimes original, potentially ground-breaking, research initiatives may be less prone to generate manuscripts which may require years, if ever, to gain scientific appraisal.[14,15] Notwithstanding these considerations, however, the findings of the present publication analysis revealed that the contact lens field is a fertile area of research, with well-defined, evolving topics of interest that may promise a rewarding future for those researchers working in this particular discipline of science.

Conflicts of interest

None of the authors have any proprietary interests or conflicts of interest related to this submission.

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