

1 **TITLE:** **PUBLICATION ANALYSIS OF THE CONTACT LENS FIELD: WHAT ARE THE**
2 **CURRENT TOPICS OF INTEREST?**

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30 **ABSTRACT**

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

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

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

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

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51 **KEY WORDS**

52 Authors; Contact Lens; Impact Factor; Institutions; Key Words; Research Interests

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54

55 **INTRODUCTION**

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

65 In a seminal paper by Efron, Brennan and Nichols published in January 2012 the authors
66 performed a complete citation analysis of the contact lens field, from the first article by Adolf
67 Fick, dating from 1888, to February 2011³. Efron and co-workers examined all subject
68 categories of the “Science Citation Index Expanded” database by following a search strategy
69 consisting of providing the search engine of the Web of Science (Thomson Reuters, New York,
70 NY) with a list of commonly employed terms in the contact lens field. After further refining
71 their research, a total of 3096 articles were compiled, whereupon the most highly cited,
72 influential papers were identified and the leading authors, source journals, institutions and
73 countries associated with those articles were acknowledged.

74 Citation analysis is a useful approach for assessing the quality of research in a given field,
75 based on the assumption that influential articles are more frequently cited by other
76 researchers and clinicians. As such, abundant citation analysis literature exists, either
77 examining the *Ophthalmology* subject category in general⁴⁻⁶, or a particularly relevant
78 subspecialty (such as dry eye)^{7,8}. However, *per definition*, citation analysis uncovers the most
79 highly cited articles of a given time period. Therefore, it may not be the best approach to

80 determine the current topics of interest of a scientific discipline, with potentially high impact
81 recent articles requiring several years to show a clear trend regarding their citation count⁸.
82 This effect was evident upon exploring the 10 most highly cited articles in the contact lens field
83 (ranked by citation count), with the most recent paper dating from 1999 (although an analysis
84 by citation frequency, that is, cites per year, unveiled more recent research contributions)³. In
85 addition, it has been documented that, in general, basic and diagnostic research areas have an
86 above average citation impact, in detriment of clinical research⁹, which may result in
87 unwanted bias if citation analysis is employed to review current research trends.

88 The aim of the present study was to determine the current topics of research interest in the
89 contact lens field. For this purpose, all articles published in the 2011 issues of all journals
90 included in the JCR subject category *Ophthalmology* were visually inspected in order to expose
91 those papers related to the contact lens field, whereupon a comprehensive list of key words
92 was compiled for further evaluation. In addition, information regarding source title (journal
93 name) and language of the article was obtained to identify the main target journals for contact
94 lens researchers and clinicians. Finally, authorship details (name of the authors, institutions
95 and country of origin) were also recorded and analysed to determine the top most prolific
96 authors, institutions and countries in the contact lens field in 2011.

97 **METHODS**

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

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

112 This process uncovered a total of 156 articles, published in 28 different journals. The full
113 version of these articles was downloaded and the following information was recovered: title of
114 the article, journal name, language or languages of the article, list of authors (only the first 3
115 authors were included, as this value was considered the median number of authors per paper),
116 institution and country of first author (or corresponding author, if different) and key words
117 provided by the authors (up to 5 key words per article were recorded and considered a “group
118 of key words”).

119 Key words were first submitted to a detailed visual inspection aimed at, on the one hand,
120 converting all plural terms into singular ones (for example, from “contact lenses” to “contact
121 lens”) and, on the other hand, building a thesaurus file with which to merge different

122 synonyms into a single term (for example, “rigid gas permeable”, “gas permeable”, “RGP”,
123 etc.). Following this step, a text file (corpus file) was generated by introducing key words into a
124 simple text editor (Notepad for Windows) so that each line of text included all key words of a
125 single article (group of key words). This corpus file was then imported into VOSviewer version
126 1.5.4 (© 2013 Centre for Science and Technology Studies, Leiden University, The Netherlands;
127 freely available at: <http://www.vosviewer.com/>) for Windows¹⁰.

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

142 **RESULTS**

143 **Table 1** displays the top journals with more than 4 published articles related to contact lenses.
144 Information is provided regarding name and country of publisher, language or languages of
145 published articles, issues per year, number of articles published in 2011, number and
146 percentage of contact lens related articles and 2-year impact factor and rank amongst the
147 journals listed under the *Ophthalmology* subject category. It is interesting to note that,
148 whereas in total number of contact lens related articles, *Contact Lens & Anterior Eye*, *Eye &*
149 *Contact Lens* and *Optometry and Vision Science* are tied at the first rank, with 27 articles each,
150 this position is occupied by *Contact Lens & Anterior Eye* alone when examining the ratio of
151 contact lens related articles over total number of articles (54%).

152 Authors with more than 3 articles in the contact lens field in 2011 are summarized in **Table 2**,
153 together with their institution and country of origin. It may be noted that 5 out of the 7 articles
154 of the most prolific author, Professor Philip Morgan, from the Faculty of Life Sciences at the
155 University of Manchester, England, are in shared authorship with the second most prolific
156 author, Professor Nathan Efron, from the Institute of Health & Biomedical Innovation, School
157 of Optometry and Vision Sciences, Queensland University of Technology. These articles, mainly
158 published in *Contact Lens & Anterior Eye*, describe diverse surveys aiming at exploring regional
159 and/or international contact lens prescription trends and compliance attitudes.

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

165 All articles were written entirely in English, with the exception of 2 papers in German and
166 another 6 in which a copy of the abstract was also available in a language different than
167 English (French, Chinese, German and Standard Hindi).

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

175 **DISCUSSION**

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

180 Citation analysis of a given discipline often follows a different approach. In effect, Efron and
181 co-workers, in their analysis of citation in the contact lens field³, presented the Web of Science
182 database search engine with a list of terms the authors considered to be representative of the
183 contact lens field. In addition, the search was neither circumscribed to the *Ophthalmology*
184 subject category, encompassing instead the whole "Science Citation Index Expanded", which
185 includes about 5000 journals of diverse disciplines, nor to latest edition of the JCR. This
186 strategy resulted in the precise identification of the most highly cited articles of all time in the
187 contact lens field, irrespective of the subject category under which their respective source title
188 (journal) was classified, with many of the top ranked contributions originating from subject
189 areas such as medicine or material sciences, that is, although it provided a detailed historical
190 account of the contact lens publications up to the present date, current topics of interest were
191 too recent to be accurately uncovered by citation analysis alone.

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

199 It must be noted that the present approach is only able to provide a one-year snap-shot of the
200 field, which may be misleading, and that, without information on the future citation of the
201 relevant articles, undue credit may be given to papers, or to prolific authors, which may not
202 truly reflect important advancements in the field. As it has been documented that citations to
203 articles published in a given year increase to a maximum between two and a six years after
204 publication¹¹, citation analysis of articles published in 2011 shall be the subject of a future
205 study. The findings of that study should be able to determine the validity of the preliminary
206 assumptions offered by the present data.

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

216 It is interesting to note that, according to the 2011 JCR Science Edition database, the total
217 number of articles published in 2011 in journals listed in the subject category of
218 *Ophthalmology* was of 8319. Therefore, it may be observed that contact lenses constitute a
219 very limited percentage (1.88%) of all papers published in the ophthalmic literature. Indeed,
220 Efron and co-workers, in their citation analysis of the contact lens field³, uncovered a total of
221 3096 contact lens related articles published between 1888 (actually 1960) and 2010, with a
222 yearly number of articles between 100 and 150 in recent years, in agreement with the present
223 findings. As Efron and co-workers did not restrict their search to the *Ophthalmology* subject

224 category, this agreement may be an indication that the number of contact lens related articles
225 published outside this area may represent only a small fraction of the total of contact lens
226 articles.

227 The analysis of the most prolific authors, institutions and countries did not expose unexpected
228 findings. Indeed, a large portion of articles originated from authors from countries, such as
229 USA, Canada, England and Australia, with long research tradition in the contact lens field,
230 although it was also disclosed that authors from non-English speaking countries such as Spain,
231 China or Japan are slowly gaining voice in this area of clinical research. These results,
232 notwithstanding the differences in approach described above, are not in disagreement with
233 the findings of Efron and co-workers³. It must be noted that no attempt was made to
234 normalize country data by taking into account the *article per capita* ratio, as it was believed
235 that a more realistic approach would be to estimate other factors, such as the number of
236 licensed optometrists, research institutions, universities with an Optometry Department, etc.
237 These considerations, however, were beyond the scope of the present study.

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

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

260 The use of publication analysis to explore topics of interest has an intrinsic, obvious limitation:
261 only published articles are entered into the analysis, that is, this approach may reflect not only
262 the efforts of researchers but also the policies and preferences of the editorial boards and/or
263 reviewers of the journals regarding manuscript acceptance. In addition, a large number of
264 scientists, mainly working for the contact lens industry, may be under temporal non-disclosure
265 agreements regarding their research. The inclusion of data from articles that did not reach
266 publication may be able to provide a better, overall indication of the research being
267 performed⁷. However, it must be observed that research impact and clinical impact may not
268 necessarily reflect the same concept, as a particular article may be useful to guide clinical
269 decisions even though it receives relatively few citations in the scholarly literature¹².

270 All information regarding trending topics of research may be treated as a double-edged-sword.
271 Thus, on the one hand, it may encourage scientists to work in popular areas of research in
272 which published articles are more susceptible to be cited by their peers, a factor that may also
273 influence the editorial decisions of those journals aiming at improving their impact factor¹³. On

274 the other hand, more obscure, risky, albeit sometimes original, potentially ground-breaking,
275 research initiatives may be less prone to generate manuscripts which may require years, if
276 ever, to gain scientific appraisal^{14,15}. Notwithstanding these considerations, however, the
277 findings of the present publication analysis revealed that the contact lens field is a fertile area
278 of research, with well-defined, evolving topics of interest that may promise a rewarding future
279 for those researchers working in this particular discipline of science.

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310 **TABLES**

311 **Table 1:** Journals with more than 4 articles in the contact lens field, with indication of name
 312 and country of publisher, language, issues per year (i/y), number of articles published in 2011
 313 (n), number (nCL) and percentage (%CL) of contact lens related articles and 2-year impact
 314 factor (IF) and rank in the *Ophthalmology* subject category (JCR 2011 edition).

315

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

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318 **Table 2:** Authors with more than 3 articles in the contact lens field, with indication of number
 319 of articles (nCL), institution and country of origin.

320

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

322 ^a Includes: Eurolens Research

323 ^b Includes: Centre for Contact Lens Research

324

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

328

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

330 ^a Includes: Centre for Contact Lens Research

331 ^b Includes: Eurolens Research

332

333 **Table 4:** Countries with more than 3 articles in the contact lens field, with indication of number
334 of articles (nCL).

335

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

336

337

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

341

	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

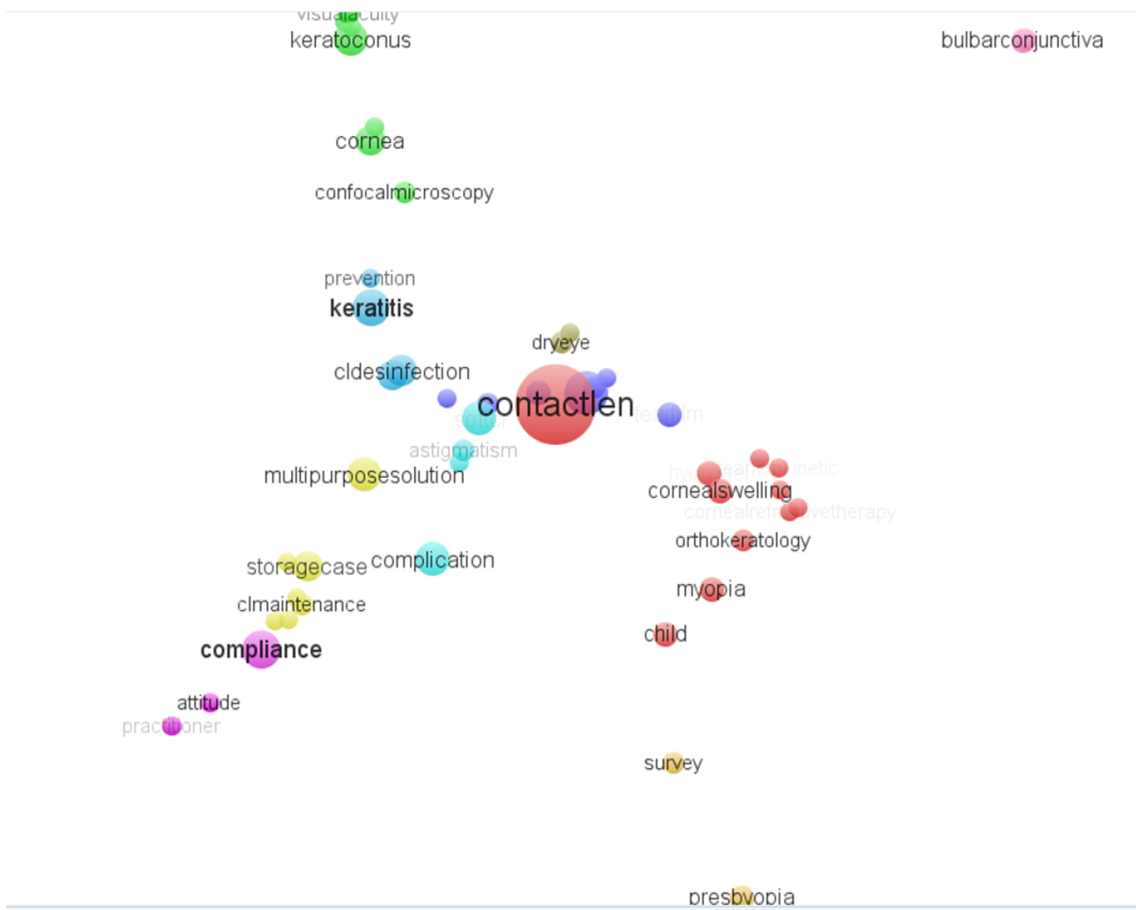
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344 **FIGURES**

345 **Figure 1:** Term map generated with VOSviewer v.1.5.4. Size of labels is an indication of
346 frequency of occurrence of each key word and different colors represent word clusters. In
347 general, the shorter the distance between two terms, the closer their relation (higher number
348 of co-occurrences in groups of key words) (*please note that some spelling liberties were*
349 *required for VOSviewer to correctly manage key words*).

350



351