Open access to journal articles in dentistry

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Open Access to Journal Articles in Dentistry: Prevalence and Citation Impact

Fang Hua [a *] Heyuan Sun [b] Tanya Walsh [a] Helen Worthington [a] Anne-Marie Glenny [a]

[a] *Cochrane Oral Health Group, School of Dentistry, The University of Manchester, Oxford Rd, M13 9PL, United Kingdom*

[b] *Faculty of Life Sciences, The University of Manchester, Oxford Rd, M13 9PT, United Kingdom*

***** *Corresponding Author:*
Fang Hua, Cochrane Oral Health Group, School of Dentistry,
The University of Manchester, JR Moore Building,
Oxford Rd, Manchester, M13 9PL, United Kingdom.
E-mail address: drfanghua@outlook.com

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Open Access to Journal Articles in Dentistry:

Prevalence and Citation Impact

Abstract

Objectives: To investigate the current prevalence of open access (OA) in the field of dentistry, the means used to provide OA, as well as the association between OA and citation counts.

Methods: PubMed was searched for dental articles published in 2013. The OA status of each article was determined by manually checking Google, Google Scholar, PubMed and ResearchGate. Citation data were extracted from Google Scholar, Scopus and Web of Science. Chi-square tests were used to compare the OA prevalence by different subjects, study types, and continents of origin. The association between OA and citation count was studied with multivariable logistic regression analyses.

Results: A random sample of 908 articles was deemed eligible and therefore included. Among these, 416 were found freely available online, indicating an overall OA rate of 45.8%. Significant difference in OA rate was detected among articles in different subjects ($P<0.001$) and among those from different continents ($P<0.001$). Of articles that were OA, 74.2% were available via self-archiving ('Green road' OA), 53.3% were available from publishers ('Gold road' OA). According to multivariable logistic regression analyses, OA status was not significantly associated with either the existence of citation ($P=0.37$) or the level of citation ($P=0.52$).

Conclusions/Clinical Significance: In the field of dentistry, 54% of recent journal articles are behind the paywall (non-OA) one year after their publication dates. The 'Green road' of providing OA was more common than the 'Gold road'. No evidence suggested that OA articles received significantly more citations than non-OA articles.

1. Introduction

Open Access (OA), free online access to journal articles without any restrictions posed by subscriptions, is a recent revolution in scientific publishing made possible by the Internet (1). By disseminating research findings to the largest possible readership, OA is believed to accelerate research, enrich education, and benefit all stakeholders including researchers and practitioners, especially those in low-income countries and resource-poor institutions (2-4). Also, it is a recommended measure to reduce avoidable waste in biomedical research (5).

Since the release of the Budapest Open Access Initiative (BOAI) in 2002, numerous efforts have been made by governments, funders, institutions and publishers to promote OA (6, 7). In April 2008, the US National Institutes of Health (NIH) began to require that all grantees submit to PubMed Central (PMC) their final manuscripts upon acceptance for publication, to be made OA no later than 12 months after the publication date (8). The same year also saw the establishment of the Harvard OA mandate (9). Thereafter, many funding/government agencies and institutions across the world followed suit (10). As of December 2015, a total of 750 OA mandates have been registered on the ROARMAP website (roarmap.eprints.org), representing a five-fold increase since January 2005.

Due to the abovementioned importance of OA and efforts/resources devoted to its development, it is crucial to assess periodically the prevalence of OA and relevant characteristics using a precise and comprehensive approach (1). Although the OA status of biomedical articles has been investigated in several previous studies (6, 11), to our knowledge, there has been no such study in the field of dentistry. In addition, the 'citation advantage' of OA has been under debate (12). Whether OA articles in dentistry receive more citations than non-OA articles still remains unstudied.

Therefore, the objectives of this study were:

- To determine the prevalence of OA among journal articles in the field of dentistry;
- To analyse the current means used to make these articles OA; and
- To investigate the association between OA and citation count.

2. Materials and Methods

2.1. Sample Creation

2.1.1. Search strategy

As in previous similar research (6, 11), the sample was selected from the PubMed database due to its popularity in the biomedical field. The electronic search was conducted on 13 Feb 2015 to identify dental journal articles published during the year of 2013 (**Table 1**). A follow-up of slightly more than one year was deemed appropriate because 12 months is the maximum embargo that NIH permits (8); most publishers allow authors to self-archive their articles after a 12-month delay; and that many journals make their contents OA after an embargo period ('delayed OA') of one year (1, 13).

2.1.2. Random selection

The PubMed search yielded a total of 9101 items. We extracted all these items using the 'send to file' function of PubMed, and transferred the data into an Excel (Microsoft) spreadsheet using the Endnote software (version X7, Thomson Reuters). Then from the 9101 items, 1000 items were randomly chosen using an online random number generator.

2.1.3. Eligibility criteria

In this study, we sought to investigate the OA status of journal articles that were original, peer-reviewed and of direct relevance to dental health professionals and/or dental researchers. Thus we decided *a priori* to exclude 1) editorials and letters; and 2) articles that were not about dentistry: those that were assigned the MeSH term "dentistry" by mistake, and those regarding forensic and veterinary dentistry. After application of these criteria, 92 items were excluded, resulting in a final sample of 908 items (**Figure 1**).

2.2. Data Extraction

For each included article, the following information was extracted from PubMed: title of article, title of journal, type of journal, authors' names, geographic location of the first author, subject of article, study type, publication date, and the corresponding PMID. Additionally, in May 2015, the citation count of each article was collected

from Google Scholar, Scopus and Web of Science, respectively.

Journals were divided into two types according to relevant information provided on the DOAJ (Directory of Open Access Journals) and Ulrich's Periodicals Directory websites: 1) OA journals (OAJs) which make all articles freely available, usually with 'article processing charges' levied on the authors; and 2) subscription journals (also referred to as 'toll-access' journals) which are only accessible to subscribers or readers who pay on a pay-per-view basis, and usually available both in print and electronically. Some subscription journals allow authors to pay for individual papers to be designated OA. These journals are termed 'hybrid OA' journals.

For the subject of the article, a categorization method was developed based on the definitions of the UK General Dental Council specialist lists (14). The study type of each article was determined according to established methods and relevant literature (15-17). When the information provided on PubMed for an article was inadequate (e.g. author location, subject of article, study type), the corresponding full-text was retrieved for data extraction.

2.3. Assessment of OA Status

2.3.1. Sources

The OA status of each included article was checked by searching four commonly used online search engines/databases:

- Google: The search term was the full title of article, combined with the first author's name if the title was too short and/or too broad, generating obviously irrelevant search results. Like in previous similar research (6, 11), only the first 20 results were examined.
- Google Scholar: Same as Google, search term was the full title of article, combined with the first author's name if necessary. All search results were examined. If the target article was found, all sources of the article were checked using the 'All versions' function.
- PubMed: First, the corresponding PubMed webpage was obtained by searching the article title or the PMID. Then all hyperlinks provided in the 'LinkOut – more resources' section were examined, including those under the subheadings of 'Full Text Sources' (usually publisher's or journal's website, the PMC webpage) and

'Other Literature Sources' (usually the ResearchGate webpage and others).

- ResearchGate (www.researchgate.net): Full article titles were searched using the 'Publications' search tool of ResearchGate. The corresponding webpage, if found in the search results, was examined for full-text.

If no full-text could be freely accessed through any of the above four engines/databases, a supplementary search was carried out by searching the full article title in the OAIster database (*via* WorldCat.org) and the 'articles' search tool of DOAJ.

2.3.2. Standards

When a potential full-text document or webpage was identified, we examined its content to see: 1) whether it was the article that we searched for (same title, author names, journal title, publication date); and 2) whether it was a full-text (full length, provision of tables, figures and references). Both publisher's version full-texts (copy-edited) and the authors' version full-texts ('pre-print' or 'post-print', before copy-editing) were accepted as OA articles.

2.3.3. Documentation

A dichotomous OA status outcome was documented for each search. If the search results included at least one direct hyperlink to an OA full-text, the OA status for the corresponding search was documented as 'Yes'; otherwise, 'No'. Then, the OA status of each article was recorded by summarizing the results of all relevant searches: 'Yes', if the full-text could be freely accessed via at least one of the searched databases; and 'No', if none of the searches identified OA full-texts.

In addition, for each OA full-text that was found, we documented the corresponding URL (Uniform Resource Locator). When multiple OA sources existed for one article, the URLs of all sources were recorded. Then, based on these sources, the OA type of each article was coded into three categories according to the 'two roads to OA' described in BOAI (11):

- 'Gold road' only: the article was only OA on the journal or publisher's website;
- 'Green road' only: the article was only OA through self-archiving;

- Both roads: the article was OA via both the Gold and Green routes.

Further, for full-texts that were available in Gold OA, we classified their sources into two categories according to their journal type (publishing model):

- OAJs;
- Subscription journals (including 'hybrid OA' and 'delayed OA').

For full-texts that were OA via the Green route, their sources were recorded as:

- PMC;
- ResearchGate;
- Repositories other than the PMC (institutional repositories, public repositories);
- Other websites (e.g. personal websites, industry websites).

2.3.4. Assessment process

After initial calibration, two authors (F.H. and H.S.) assessed the OA status of 20 randomly chosen articles independently and in duplicate. The inter-examiner agreement was good with no discrepancy detected. The same two authors then carried out the assessment of the remaining articles independently. One author (F.H.) subsequently checked all assessment results and coding of classifications. The calibration and assessment processes were conducted during Feb to April 2015, using a residential IP (Internet Protocol) address at Manchester, UK, with no access to any electronic subscription or library services.

2.4. Statistical Analyses

Chi-square tests were used to compare the OA rates of articles in different subjects, different study type, and from different continents. In addition, for each article, the average citation count (ACC) was calculated by averaging the citation count provided in Google Scholar, Scopus and Web of Science. We then compared the ACC of OA articles and non-OA articles using the Mann-Whitney U test. To further adjust for the potential effects of subject, study type and continent of origin on citation count, we entered these three variables together with OA status into two logistic regression

analyses: one conducted for all included articles with existence of citation as the dependent variable (cited vs. not cited); and the other one carried out on cited articles only, with different levels of ACC as the dependent variable (0<ACC<3 vs. ACC≥3). The goodness of fit was assessed with the Hosmer & Lemeshow test. Statistical significance was defined as $P<0.05$.

3. Results

3.1. Characteristics of Included Articles

In terms of study type, 83.2% of the articles were primary research and 16.8% were secondary research (reviews). Among primary research articles, almost one third (30.9%) were basic science studies where experiments were performed on animals, cells, extracted teeth and digital devices etc. About 13% of all included articles were of high level of clinical evidence (randomised controlled trials and systematic reviews). Additionally, among six continents, Europe contributed the most articles (36.6%), followed by Asia (26.4%) and North America (19.3%). (**Table 2**)

3.2. Prevalence of OA

Among the 908 articles included, a total of 416 were freely available, indicating an overall OA rate of 45.8% (95% CI: 42.6, 49.1). The OA rate varied significantly among articles in different subjects ($P<0.001$), ranging from 20.0% in oral clefts research to 69.3% in orthodontics. Significant difference was also detected among articles from different continents ($P<0.001$). 69.1% of articles from South America were OA, while the OA rates of articles from Oceania and Asia were less than 40%. No significant difference in OA rate was found among different study types ($P=0.60$). (**Table 3**)

In this study, nearly 85% of all included articles were from eighteen countries (each with a sample size≧15). The OA rate of these countries ranged widely, from 12.5% for Israel to 70.7% for Brazil. (**Figure 2**)

3.2.1. Effectiveness of search tools used

The OA rate indicated by Google, Google Scholar, PubMed (‘LinkOut’) and

ResearchGate each separately was 29.4%, 36.8%, 35.6% and 24.8%, respectively. Google Scholar searches alone identified 80.3% of all OA full-texts found by using four search tools together. (**Table 4**) No OA full-text was found in the supplementary searches using OAIster and DOAJ.

3.3. Methods of Providing OA

Among the 416 OA articles, 194 (46.6%) were only available through self-archiving (Green OA); 107 (25.7%) were only available from the publisher (Gold OA); the rest (27.6%) could be accessed via both the Green and Gold routes.

The methods of providing OA varied among different subjects, study types and continents of origin (**Table 5**). In OA articles regarding oral implantology, as much as 77.8% were only OA because of self-archiving. While in OA articles about dental and maxillofacial radiology, 90.0% were Gold OA. In terms of study type, a relatively high rate of self-archiving was found in randomised controlled trials (88.6%) and systematic reviews (82.4%). Whilst the highest proportion of Gold OA (67.1%) was seen in cross-sectional studies. Additionally, self-archiving was used more often by authors from Africa (83.3%) and Europe (82.5%), while Gold OA publishing was most popular in authors from Asia (65.2%). **Figure 2** shows the OA type breakdown of articles from each of the eighteen main countries (sample size$\geqq$15).

Further analyses of the sources of OA articles suggested that, for articles that were Gold OA, about one half were from OAJs (49.1%) and the other half from subscription journals (50.9%). For articles that were OA through self-archiving, 72.8% could be accessed at ResearchGate, 23.3% at PMC, 15.5% at institutional/public repositories other than the PMC, and 15.5% at other websites. (**Table 6**)

3.4. Citation Impact of OA

Based on the results of Mann-Whitney U tests, no significant difference was found in the average citation count (ACC) between OA articles and non-OA articles, in the overall sample (P=0.80) or any of the subsets grouped by subject, study type and continent (P>0.05). (**Table 7**)

In the logistic regression analysis regarding existence of citation (cited vs. not cited), OA articles were not significantly more likely to be cited than non-OA articles

(P=0.37). However, study type was a significant predictor of citation (P<0.001). Narrative reviews were significantly less likely to be cited than all other study types, except case reports/series and case-control studies. (**Table 8**)

According to the logistic regression regarding citation level (0<ACC<3 vs. ACC⩾ 3), among articles that were cited, OA articles were not significantly more likely to be cited three times or more (P=0.52). However, study type (P<0.001) and continent of origin (P=0.02) were found to be significantly associated with citation level. Compared with narrative reviews, articles describing basic science research, case-control studies, randomised controlled trials and systematic reviews were significantly more likely, and articles describing case reports/series were significantly less likely, to be cited three times or more (P<0.05). Additionally, articles from South America were 53% less likely (P=0.01) than those from Europe to have an ACC of no less than three. (**Table 9**)

4. Discussion

4.1. The Status of OA

4.1.1. Prevalence

Based on a labour-intensive manual check of relevant articles obtained from the PubMed, which has been recognized as the most comprehensive approach for OA status research (1, 6), this study found that 46% of dental articles published in 2013 were freely available online in 2015.

To our knowledge, only three previous studies have looked at the OA status of articles in biomedicine using methodologies similar to ours. Matsubayashi and colleagues found that the OA rate of biomedical literature increased substantially from 27% in 2006 (11) to 50% in 2010 (6). Bjork *et al* (1) reported that the OA rate of journal articles in 2009 was 22% for 'medicine' and 15% for 'other areas related to medicine'. However, direct comparison between these studies and the present study is complicated by methodological differences, such as the scope, base year, sampling method, and search tools used (**Table 10**).

4.1.2. Methods of providing OA

The results of this study suggest that among dental articles that are OA, 74% were

available via self-archiving (Green OA) whereas 53% were available from publishers (Gold OA). This contradicts previous research's finding that, in the filed of biomedicine, Gold OA has been the dominant method for achieving OA (1, 6). Such differences could be resulted from the aforementioned methodological differences. But another possible explanation is the rapid growth of OA mandates (10) and the ResearchGate website during recent years. Since its foundation in 2008, ResearchGate has accumulated more than seven million users, with medicine being the fastest growing discipline (18). However, little attention was paid to this website in previous OA research. In this study, as many as 225 articles were available in ResearchGate, representing 25% of the overall sample and 73% of all Green OA articles. This suggests that ResearchGate is very popular among dental researchers and has become a major OA repository in the field of dentistry.

Another thing worth noting is the surprisingly high share of publisher's version (copy-edited) copies among Green OA full-texts, which has also been found in previous studies (1). Currently, major publishers of subscription journals only allow the self-archiving of authors' version (before copy-editing) copies, and require proper attribution to the journal as the original place of publication. Before self-archiving articles, authors should read carefully the publishers' copyright policies and make sure the copies that they deposit are legal. Such policies can be found on an authoritative website (www.sherpa.ac.uk/romeo/).

4.2. Citation impact of OA

Citations have been used as an indicator of the scientific impact of articles and, in many fields, the basis of professional reward (19). Since 2004, many studies (from various scientific fields) have reported that OA articles are cited significantly more than non-OA articles (20). However, recent reviews pointed out that these earlier studies suffered from methodological problems (e.g. lack of control for confounding variables), and that the 'citation advantage' they found appeared to be artefacts of improper analyses (12, 20).

In the present study, there was no evidence to support the existence of OA 'citation advantage', or the idea that OA increases the citation of citable articles (21). These findings are in keeping with those of several recent randomised controlled trials (19,

22), in which OA articles were found to receive significantly more downloads, but no more, nor earlier, citations than subscription-access control articles. The main beneficiaries of OA may not be scientific authors who traditionally have adequate access to the scientific literature, but people outside the research community, who use, but rarely contribute to, the body of literature (19).

Additionally, through multivariable logistic regressions, we found that study type was a significant predictor of both the existence and level of citation, showing a stronger association with citation counts than OA status, subject and continent. Articles covering basic science research and those describing high evidence level clinical studies (e.g. systematic reviews, randomised controlled trials) were more likely to receive citation and more likely to be cited three times or more. This finding is consistent with those of several previous studies in dentistry (23) and medicine (24).

4.3. Limitations and strengths

This study has several limitations. First, like previous research on OA status, our study is a single-site assessment conducted in the United Kingdom. Our assessment results may not represent the situation in other parts of the world. For example, the *Cochrane Database of Systematic Reviews* offers free online access but only for residents in several countries/regions with a national funded license and those in low- and middle-income countries as defined by the WHO (25). Second, the citation impact component of this study, an observational retrospective study in essence, has not taken into account all known and unknown confounding factors. Relevant results could be revisited in the future, preferably by publishers and researchers collaboratively using a randomised controlled trial (19).

Despite these limitations, our study has several strengths. To our knowledge, this study is the first of its kind to: 1) provide insight into OA in the field of dentistry; 2) use a fully random sampling method to ensure representativeness (6); 3) provide the OA status by, and control for, ‘study type’ which is categorized from an epidemiological perspective; 4) combine the citation statistics from three databases (Google Scholar, Web of Science and Scopus) to improve comprehensiveness; and 5) explore the role of ResearchGate in OA.

5. Conclusion

The results of this study indicate that, in the field of dentistry:

- More than one half (54%) of recent journal articles are behind the paywall (non-OA) one year after their publication dates;
- The ‘Green road’ (via self-archiving) of providing OA was more common than the ‘Gold road’ (from publishers);
- No evidence suggested that OA articles received significantly more citations than non-OA articles.

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Tables

Table 1. The search strategy used for sample creation.

Database	Search Strategy	Number of Hits
PubMed	("dentistry"[MeSH Terms]) AND ("2013/01/01"[Date - Publication] : "2013/12/31"[Date - Publication]) NOT ("editorial"[Publication Type] OR "letter"[Publication Type])	9101

Table 2. Characteristics of included studies

Characteristic	Category	N	%
Subject	Oral and maxillofacial surgery	138	15.2
	Orthodontics	127	14.0
	Oral implantology	100	11.0
	Prosthodontics	87	9.6
	Dental public health	85	9.4
	Periodontics	73	8.0
	Endodontics	51	5.6
	Restorative dentistry	49	5.4
	Paediatric dentistry	43	4.7
	Dental materials	43	4.7
	Special care dentistry	26	2.9
	Dental and maxillofacial radiology	22	2.4
	Oral clefts	10	1.1
	Other	54	5.9
Study type	Basic science	233	25.7
	Case report/series	138	15.2
	Case control	9	1.0
	Cohort	74	8.1
	Cross-sectional	176	19.4
	Randomised controlled trial	85	9.4
	Nonrandomised/uncontrolled trial	41	4.5
	Systematic review	35	3.9
	Narrative review	117	12.9
Continent	Asia	240	26.4
	Africa	15	1.7
	Europe	332	36.6
	North America	175	19.3
	Oceania	23	2.5
	South America	123	13.5
Total		908	100

N: number of studies.

Table 3. OA rate by subject, study type, and continent of origin.

Characteristic	Category	N		OA rate	P value [a]
		Not OA	OA	% (95% CI)	
Subject	Oral and maxillofacial surgery	87	51	36.96 (29.36, 45.26)	P<0.001
	Orthodontics	39	88	69.29 (60.80, 76.65)	
	Oral implantology	64	36	36.00 (27.27, 45.76)	
	Prosthodontics	56	31	35.63 (26.37, 46.11)	
	Dental public health	45	40	47.06 (36.81, 57.57)	
	Periodontics	47	26	35.62 (25.61, 47.07)	
	Endodontics	27	24	47.06 (34.05, 60.48)	
	Restorative dentistry	24	25	51.02 (37.47, 64.42)	
	Paediatric dentistry	21	22	51.16 (36.75, 65.38)	
	Dental materials	20	23	53.49 (38.92, 67.49)	
	Special care dentistry	15	11	42.31 (25.55, 61.05)	
	Dental and maxillofacial radiology	12	10	45.45 (26.92, 65.34)	
	Oral clefts	8	2	20.00 (5.67, 50.98)	
	Other	27	27	50.00 (37.12, 62.88)	
Study type	Basic science	116	117	50.21 (43.84, 56.58)	P=0.60
	Case report/series	80	58	42.03 (34.12, 50.37)	
	Case control	5	4	44.44 (18.88, 73.33)	
	Cohort	39	35	47.30 (36.34, 58.52)	
	Cross-sectional	97	79	44.89 (37.73, 52.27)	
	Randomised controlled trial	50	35	41.18 (31.32, 51.80)	
	Nonrandomised /uncontrolled trial	18	23	56.10 (41.04, 70.11)	
	Systematic review	18	17	48.57 (33.00, 64.43)	
	Narrative review	69	48	41.03 (32.54, 50.09)	
Continent	Asia	148	92	38.33 (32.41, 44.62)	P<0.001
	Africa	9	6	40.00 (19.83, 64.25)	
	Europe	195	137	41.27 (36.10, 46.78)	
	North America	87	88	50.29 (42.95, 57.61)	
	Oceania	15	8	34.78 (18.81, 55.11)	
	South America	38	85	69.11 (60.47, 76.95)	
Total		492	416	45.81 (42.60, 49.07)	

N: number of studies; CI: confidence interval.

[a] R * C Chi-Square tests.

Table 4. Effectiveness of each search tool used for OA status assessment.

Tool	N Identified	OA Rate (%)	Proportion among all identified OA studies (%)
Google	267	29.4	64.2
Google Scholar	334	36.8	80.3
PubMed LinkOut	323	35.6	77.6
ResearchGate	225	24.8	54.1

N: number of studies.

Table 5. OA type by subject, study type, and continent of origin.

		N (%)			
Characteristic	**Category**	**Green only**	**Gold only**	**Both**	**Total**
Subject	Oral and maxillofacial surgery	23 (45.1)	17 (33.3)	11 (21.6)	51 (100.0)
	Orthodontics	23 (26.1)	29 (33.0)	36 (40.9)	88 (100.0)
	Oral implantology	28 (77.8)	2 (5.6)	6 (16.7)	36 (100.0)
	Prosthodontics	18 (58.1)	8 (25.8)	5 (16.1)	31 (100.0)
	Dental public health	18 (45.0)	10 (25.0)	12 (30.0)	40 (100.0)
	Periodontics	15 (57.7)	5 (19.2)	6 (23.1)	26 (100.0)
	Endodontics	12 (50.0)	6 (25.0)	6 (25.0)	24 (100.0)
	Restorative dentistry	14 (56.0)	5 (20.0)	6 (24.0)	25 (100.0)
	Paediatric dentistry	12 (54.5)	6 (27.3)	4 (18.2)	22 (100.0)
	Dental materials	11 (47.8)	7 (30.4)	5 (21.7)	23 (100.0)
	Special care dentistry	3 (27.3)	4 (36.4)	4 (36.4)	11 (100.0)
	Dental and maxillofacial radiology	1 (10.0)	3 (30.0)	6 (60.0)	10 (100.0)
	Oral clefts	1 (50.0)	0 (0.0)	1 (50.0)	2 (100.0)
	Other	15 (55.6)	5 (18.5)	7 (25.9)	27 (100.0)
Study type	Basic science	58 (49.6)	23 (19.7)	36 (30.8)	117 (100.0)
	Case report/series	31 (53.4)	20 (34.5)	7 (12.1)	58 (100.0)
	Case control	2 (50.0)	1 (25.0)	1 (25.0)	4 (100.0)
	Cohort	16 (45.7)	9 (25.7)	10 (28.6)	35 (100.0)
	Cross-sectional	26 (32.9)	26 (32.9)	27 (34.2)	79 (100.0)
	Randomised controlled trial	20 (57.1)	4 (11.4)	11 (31.4)	35 (100.0)
	Nonrandomised /uncontrolled trial	10 (43.5)	5 (21.7)	8 (34.8)	23 (100.0)
	Systematic review	8 (47.1)	3 (17.6)	6 (35.3)	17 (100.0)
	Narrative review	23 (47.9)	16 (33.3)	9 (18.8)	48 (100.0)
Continent	Asia	32 (34.8)	41 (44.6)	19 (20.7)	92 (100.0)
	Africa	3 (50.0)	1 (16.7)	2 (33.3)	6 (100.0)
	Europe	65 (47.4)	24 (17.5)	48 (35.0)	137 (100.0)
	North America	52 (59.1)	23 (26.1)	13 (14.8)	88 (100.0)
	Oceania	4 (50.0)	2 (25.0)	2 (25.0)	8 (100.0)
	South America	38 (44.7)	16 (18.8)	31 (36.5)	85 (100.0)
Total		194 (46.6)	107 (25.7)	115 (27.6)	416 (100.0)

N: number of studies.

Table 6. Breakdown of Gold and Green OA articles.

OA Type	Category	N (%)
Gold	OA Journal	109 (49.1)
	Subscription Journal	113 (50.9)
Green [a]	PubMed Central	72 (23.3)
	ResearchGate	225 (72.8)
	Repositories [b]	48 (15.5)
	Other Websites	48 (15.5)

N: number of studies.

[a] The percentages for each category add up to more than 100% since multiple Green OA sources for each study were counted.

[b] Repositories other than PubMed Central.

Table 7. Average citation count (ACC) by OA state.

		Median ACC (IQR)		
Characteristic	**Category**	**Not OA**	**OA**	**P value [a]**
Subject	Oral and maxillofacial surgery	1.33 (2.67)	1.00 (3.00)	0.19
	Orthodontics	0.33 (1.67)	0.67 (2.33)	0.17
	Oral implantology	2.33 (3.67)	2.33 (4.92)	0.45
	Prosthodontics	1.50 (2.58)	1.00 (3.00)	0.33
	Dental public health	1.33 (2.83)	1.83 (3.50)	0.28
	Periodontics	2.00 (5.00)	2.67 (6.33)	0.36
	Endodontics	2.33 (5.33)	2.00 (3.04)	0.66
	Restorative dentistry	1.67 (2.92)	2.00 (4.33)	0.12
	Paediatric dentistry	0.67 (2.33)	1.00 (2.25)	0.14
	Dental materials	1.00 (4.08)	2.00 (4.67)	0.70
	Special care dentistry	1.67 (1.67)	3.00 (4.00)	0.47
	Dental and maxillofacial radiology	0.83 (4.08)	1.83 (4.75)	0.43
	Oral clefts	1.17 (2.75)	4.17 (NA)	0.15
	Other	1.33 (4.33)	0.67 (2.67)	0.37
Study type	Basic science	1.83 (4.25)	2.00 (4.33)	0.68
	Case report/series	0.33 (1.33)	0.33 (1.33)	0.90
	Case control	5.00 (5.00)	2.50 (5.50)	0.31
	Cohort	2.33 (2.67)	2.33 (3.67)	0.91
	Cross-sectional	1.67 (2.83)	1.33 (3.00)	0.58
	Randomised controlled trial	1.67 (3.42)	2.67 (3.33)	0.45
	Nonrandomised /uncontrolled trial	2.33 (2.92)	2.67 (3.00)	0.93
	Systematic review	4.50 (3.83)	3.33 (8.00)	0.68
	Narrative review	0.67 (2.33)	0.67 (2.67)	0.47
Continent	Asia	1.33 (2.67)	1.50 (3.33)	0.37
	Africa	0.67 (1.83)	0.67 (1.75)	0.75
	Europe	1.67 (3.67)	1.33 (3.00)	0.38
	North America	1.00 (3.00)	1.67 (3.92)	0.07
	Oceania	1.67 (3.33)	2.17 (3.67)	0.84
	South America	2.00 (2.42)	1.33 (2.67)	0.46
Total		1.33 (3.00)	1.33 (3.13)	0.80

IQR: interquartile range; NA: not applicable.

[a] Mann-Whitney U tests.

Table 8. Multivariate logistic regression derived odds ratios (OR) and 95% confidence intervals (CI), with existence of citation (cited vs. not cited) as the dependent variable. [a]

Independent variable	Category	OR	95% CI	P value (Wald test)
OA status	No	Reference		0.37
	Yes	1.18	(0.82, 1.69)	
Subject	Dental public health	Reference		0.09
	Oral clefts	0.55	(0.09, 3.24)	
	Endodontics	1.02	(0.33, 3.17)	
	Oral implantology	0.72	(0.28, 1.80)	
	Dental materials	0.33	(0.11, 0.98)	
	Oral and maxillofacial surgery	0.60	(0.26, 1.40)	
	Orthodontics	0.30	(0.13, 0.69)	
	Paediatric dentistry	0.34	(0.13, 0.90)	
	Periodontics	0.98	(0.35, 2.75)	
	Prosthodontics	0.56	(0.23, 1.36)	
	Dental and maxillofacial radiology	0.55	(0.15, 2.05)	
	Restorative dentistry	0.48	(0.17, 1.30)	
	Special care dentistry	0.46	(0.15, 1.48)	
	Other	0.37	(0.15, 0.93)	
Study type	Narrative review	Reference		<0.001
	Basic science	3.69	(2.02, 6.75)	
	Case report/series	0.80	(0.46, 1.39)	
	Case control	1.83	(0.34, 9.73)	
	Cohort	3.72	(1.62, 8.55)	
	Cross-sectional	2.48	(1.37, 4.48)	
	Randomised controlled trial	2.88	(1.34, 6.23)	
	Nonrandomised /uncontrolled trial	6.95	(1.95, 24.73)	
	Systematic review	5.30	(1.49, 18.88)	
Continent	Europe	Reference		0.74
	Asia	0.77	(0.49, 1.20)	
	Africa	0.52	(0.15, 1.80)	
	North America	0.88	(0.54, 1.43)	
	Oceania	1.51	(0.40, 5.61)	
	South America	0.90	(0.50, 1.61)	

[a] Model summary: Dependent variable coding: [0] not cited, [1] cited; No. (less common event)=187; P(Hosmer & Lemeshow)=0.866; R^2 (Nagelkerke)=0.149.

Table 9. Multivariate logistic regression derived odds ratios (OR) and 95% confidence intervals (CI), with the level of average citation count (0<ACC<3 vs. ACC⩾3) as the dependent variable. [a]

Independent variable	Category	OR	95% CI	P value (Wald test)
OA status	No	Reference		0.52
	Yes	1.12	(0.79, 1.59)	
Subject	Dental public health	Reference		
	Oral clefts	0.74	(0.13, 4.15)	
	Endodontics	1.47	(0.63, 3.45)	
	Oral implantology	1.66	(0.80, 3.47)	
	Dental materials	1.52	(0.59, 3.90)	
	Oral and maxillofacial surgery	1.29	(0.63, 2.66)	
	Orthodontics	0.77	(0.36, 1.62)	0.42
	Paediatric dentistry	0.97	(0.38, 2.50)	
	Periodontics	1.65	(0.78, 3.48)	
	Prosthodontics	0.85	(0.38, 1.91)	
	Dental and maxillofacial radiology	0.77	(0.23, 2.54)	
	Restorative dentistry	2.10	(0.82, 5.40)	
	Special care dentistry	0.77	(0.25, 2.36)	
	Other	1.63	(0.70, 3.84)	
Study type	Narrative review	Reference		
	Basic science	2.37	(1.26, 4.48)	
	Case report/series	0.24	(0.09, 0.65)	
	Case control	24.60	(2.67, 226.95)	
	Cohort	1.83	(0.87, 3.85)	
	Cross-sectional	1.92	(0.99, 3.70)	<0.001
	Randomised controlled trial	2.60	(1.25, 5.40)	
	Nonrandomised /uncontrolled trial	2.22	(0.93, 5.33)	
	Systematic review	6.85	(2.68, 17.48)	
Continent	Europe	Reference		
	Asia	0.78	(0.51, 1.20)	
	Africa	0.25	(0.05, 1.24)	0.02
	North America	1.28	(0.80, 2.06)	
	Oceania	0.71	(0.25, 1.99)	
	South America	0.47	(0.27, 0.82)	

[a] Model summary: Dependent variable coding: [0] 0<ACT<3, [1] ACT⩾3; No. (less common event)=258; P(Hosmer & Lemeshow)=0.997; R^2 (Nagelkerke)=0.164.

Table 10. Main methodological differences between this study and previous similar studies in biomedicine.

Study ID	Scope	Base Year [a]	Study Year [b]	Sample Source	Full Random Sampling	Search Tools Used
Current study	Dentistry	2013	2015	PubMed	Yes	Google, Google Scholar, PubMed, ResearchGate, OAIster, DOAJ
Matsubayashi (2009)	Biomedicine	2005	2006	PubMed	No	PMC, Google Scholar, Google, OAIster
Bjork (2010)	Medicine	2008	2009	Scopus	No	Google
	Other areas related to medicine	2008	2009	Scopus	No	Google
Kurata (2013)	Biomedicine	2005, 2007, 2009	2006, 2008, 2010	PubMed	No	PMC, Google, Google Scholar, OAIster

[a] The publication year of sampled articles.

[b] The year in which the OA status of sampled articles was checked.

Figures

Figure 1. Flow of included studies.

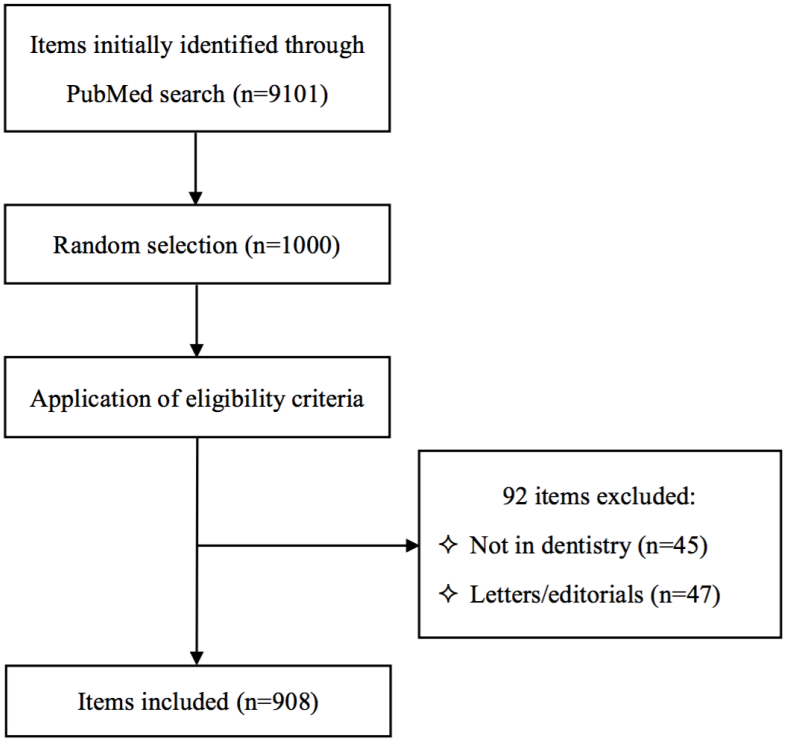

Figure 2. The OA rate and OA type of articles from eighteen main countries (sample size≧15). Numbers to the right of each bar are the sample sizes for corresponding countries.