Do randomised clinical trials on dental caries adopt Open Science Practices?

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Research Article

Keywords: Dental Caries, Randomized Clinical Trials, Open access, Data sharing, Research integrity, Open Science

Posted Date: April 3rd, 2024

DOI: https://doi.org/10.21203/rs.3.rs-4106725/v1

Additional Declarations: Competing interest reported. MMB is a senior editor of BMC Oral Health. The other authors declare that they have no competing interests.

Abstract

Background

Open Science Practices (OSPs) are essential when assessing research integrity and quality of Randomised Clinical Trials (RCTs). As dental caries represents a significant oral health burden, our objective was to identify and analyse the adoption of OSPs within RCTs focused on addressing this disease.

Methods

We searched PubMed to retrieve RCTs related to dental caries published from 2000 to March 2022. Two independent researchers assessed a random sample of these manuscripts to evaluate their eligibility until reaching the minimum sample size. Then, the same examiners reviewed the included texts regarding the OSPs adopted in the manuscripts. The collected variables related to OSPs were reporting guidelines, protocol registration, detailed methodology available, open-source software, statistical analysis code sharing, statistical analysis plan, data sharing, open peer review, and open access. Association analyses using logistic regression were conducted considering the publication year, the continent of the first author, impact factor and open-access policy of the journals (explanatory variables), and adoption of at least one OSP or one OSP other than open access (outcomes). The recommendations for adopting OSPs were assessed by reviewing the "Instructions for Authors" section of the most frequently used journals where the included papers were published.

Results

64.8% of the manuscripts (95% Confidence Interval = 59.3–70.1%) adopted at least one OSP. However, no individual OSP was adopted by more than 50% of the manuscripts. The most adopted practices were protocol registration (37.1%), the use of reporting guidelines (33.1%) and publishing open access (37.3%). These are also the OSPs most often recommended by journals in the Instructions for Authors. A few manuscripts adopted other practices. Older manuscripts presented a lower frequency of adopting these practices, and manuscripts published in higher impact factor journals were positively associated with both outcomes.

Conclusion

The RCTs published on dental caries demonstrate a low frequency of adoption of most OSPs. However, a trend toward increased adoption of these practices has been notable in recent years.

Background

Untreated dental caries is the most prevalent oral health issue, affecting approximately two billion individuals globally [1] and consistently impacting negatively their quality of life [2]. Consequently, prevention and management strategies based on the best available evidence for this public health problem are a vast need [3, 4].

Evidence-based practice is the current paradigm in healthcare, advocating the judicious use of the best available evidence to make healthcare decisions [5, 6]. Among the most relevant research designs, randomised clinical trials (RCTs) are the primary studies with the most robust evidence for evaluating health interventions' efficacy [7]. However, to yield optimal evidence these studies must be appropriately designed, conducted, and reported [8, 9].

To ensure evaluation of the quality of RCTs, every stage of the research process, from conception and design to the final publication and dissemination of the key findings, should remain transparent and accessible to all stakeholders, including other researchers, practitioners, health policy-makers and patients. This is the core principle of Open Science [10–12]. Open Science is an umbrella term associated with practices researchers can follow to make their work traceable and verifiable. While these practices would be more linked to science dissemination, they are, in fact, intertwined with “responsible research practices”, which focus on the rigorous conduct of research, and with “transparency” linked to the complete reporting of research at every stage of the research lifecycle [13]. Open science practices (OSP) enhance the assessment of research quality and issues related to transparency and integrity [14, 15] and also play a pivotal role in the acceleration of research on therapies for emerging and serious diseases, as observed during the COVID-19 pandemic [16, 17].

It is, therefore, crucial that the growing Open Science movement in the last decades, driven by the pressing demands accentuated by the pandemic, does not lose its momentum [16, 17]. This movement can potentially improve the management of public health issues, such as dental caries, by facilitating more efficient and expedited investigation of therapeutic strategies. This cross-sectional study aimed to identify OSPs on RCTs focusing on dental caries published since 2000 and evaluate factors associated with adopting these practices.

Methods

Study design

This meta-research study was carried out considering published RCTs in the field of dental caries. The protocol was registered in the Open Science Framework [18]. A survey was conducted to evaluate and record OSPs in a representative sample of RCTs related to dental caries management and published since 2000. In addition, variables associated with these practices were investigated. Although it is not a conventional systematic review, we followed the Transparent Reporting of Systematic Reviews and Meta-Analyses (PRISMA) guideline to report this manuscript. The PRISMA checklist can be accessed in the supplemental material.

Our research question was, "How often do RCTs related to dental caries adhere to various aspects of OSPs?" We searched manuscripts on the PubMed database using the following search strategy: "dental caries" OR caries OR carious OR decay OR "White spot lesion," limiting the search to studies published after 2000. The "Randomized Controlled Trial" filter was then used.

Sample size and eligibility

Based on this initial search and the main objective, a sample calculation was done using the online platform OpenEpi version 3 (www.openepi.com). With a finite population of 2,700 articles (articles available on PubMed using the proposed search strategy in March 2023), an anticipated frequency of articles that followed some

OSP of 50% and an absolute precision of 5%, the minimum number needed to be included was 324 published articles.

To select the articles, we conducted a search using the strategy described, and all the articles screened were entered into a spreadsheet and numbered in descending order according to the day of publication. A sequence of random numbers from 1 to 1000 without repetition was then created on the random.org online platform. This order was followed to include articles until the minimum sample number of articles that met the eligibility criteria was reached.

Two independent researchers (CPA and BB) evaluated the manuscripts, first through the titles and abstracts, to evaluate their eligibility. The inclusion criteria were RCTs: (A) with subjects allocated to two or more arms, (B) related to dental caries, (C) published after 2000, and (D) fully reported in English. RCTs that investigated interventions focused on students or dentists and manuscripts in which the full text was not found were excluded.

Data collection and variables

After meeting the inclusion criteria, the included manuscripts were assessed by two trained and calibrated examiners (CPA and BB) to gather data about OSPs. They were previously trained to identify those practices by joint sessions with a senior researcher (FMM). After that, they independently evaluated 30 manuscripts not included in the final sample to evaluate the agreement between the examiners. After they reached a kappa value higher than 0.70 for all assessed practices, they started to evaluate the included manuscripts.

The examiners assessed the full text of the included articles and extracted the following data: year of publication, country of the first author, and journal. They also collected the impact factor of the journals according to the 2021 Journal of Citation Reports and whether the journal follows any open access policy (subscription access, hybrid, or gold access).

The variables related to open science practices collected were:

- - Reporting guidelines: If the authors stated to follow a reporting guideline – (0) No, (1) following the CONSORT (Consolidated Standards of Reporting Trials), or (2) following other reporting guidelines.
- - Protocol registration: If the RCT had the protocol registered – (0) No; (1) Yes.
- - Open notebook or detailed methodology: If the authors presented the detailed methods in some way – (0) No, (1) Yes, in the main text; (2) Yes, as supplemental material or in an open repository.
- - Open source: If the RCT used open-source software – (0) No, (1) Yes, or (2) Unclear.
- - Data analysis script sharing: If the authors shared the script code related to their statistical analyses – (0) No; or (1) Yes.
- - Statistical analysis plan: If the RCT mentioned any publicly available statistical analysis plan – (0) No; or (1) Yes.
- - Data sharing: If the authors stated anything about data sharing – (0) No; (1) Yes, as supplemental material; (2) Yes, in public repositories; (3) Yes, upon reasonable request.
- - Open peer-review: If the journal or the authors published the peer-review process – (0) No; or (1) Yes.

- - Open access: If the paper was published in open access using any possible route – (0) No; (1) Yes, via the journal itself; (2) Yes, via PubMed Central; (3) Yes, in public repositories.

Finally, an examiner (FMM) evaluated the endorsement of OSPs of the top 15 journals where most of the included papers were published by assessing the “instructions for authors” section. This assessment was done in 2023, with no attempt to evaluate older versions. Recommendations to adopt some OSPs were assessed. Besides the journals’ open access policy, the examiner evaluated if the instructions for the authors contained the recommendations related to publishing the protocol, trial registration, following the CONSORT, following other reporting guidelines, data sharing, and other practices.

Statistical analyses

First, a descriptive analysis was conducted to present the frequency and 95% confidence intervals (95%CI) of each OSP evaluated in the included manuscripts. The frequency of adopting the main OSPs per year was plotted. Association analyses were further conducted. Explanatory variables were the year of publication (quantitative variable), the continent of the first author, the open access policy of the journal (closed or hybrid vs. gold) and the impact factor of the journal (quantitative variables). Two outcomes were evaluated: adoption of at least one OSP and adoption of one OSP other than open access.

Logistic regression was conducted for both outcomes, and the odds ratio (OR) and respective 95% CI were derived. First, univariate exploratory analyses were conducted, and then a multiple regression model was built based on the variables' significance. Only variables that had reached a p-value lower than 5% were kept in the final models. The analyses were conducted using a statistical package (Stata 15.0, Stata Corp. College Station, USA), and the significance level was set at 5%.

Results

The search for articles was performed on March 27, 2022 and 2,758 articles were retrieved. From these, 760 articles were randomly selected and assessed for eligibility. In total, 436 articles were excluded, and 324 were included in the analysis. The reasons for the manuscript’s exclusion are depicted in Fig. 1.

The included articles were published between 2000 and 2022, with an average (standard deviation - SD) years since publication (considering 2023 for the calculation) of 9.6 (6.3) years. The mean (SD) impact factor of the journals in which the included articles were published was 3.42 (2.29). Only 62 (19.1%) were published in journals with gold open access. The geographical location of the first author was Europe for 130 (40.1%) articles, Asia for 72 (22.2%), North America for 37 (11.4%), South America for 64 (19.8%), Africa for 11 (3.4%), and Oceania for 10 (3.1%) articles.

A total of 64.8% (95%CI = 59.3–70.1%) of the included manuscripts adopted at least one OSP. However, no individual OSP was adopted by more than 50% of the manuscripts, and often, there was 0% adherence in others. The most prevalent OSP was open access, with approximately 40% of the articles (Table 1). In around a third of the articles, the authors stated that they considered reporting guidelines for writing the manuscript (CONSORT, especially), and less than 40% of the RCTs were registered. The use of open-source software was absent or unclear in 96%, and the availability of details on methodology, statistical analysis plans or analysis scripts was (almost) completely absent. Only 13 manuscripts indicated data sharing would be available upon

request, and just two articles reported data availability in public repositories. However, we encountered difficulty accessing the data via the link provided in one of these manuscripts.

Table 1
Descriptive analysis considering the open Science practices adopted by the manuscripts analysed (n = 324)

Open Science practices	N	%
Report guideline		
No	217	67.0
CONSORT	101	31.2
Others	6	1.9
Protocol register		
No	204	63.0
Yes	120	37.0
Detailed methodology		
No	322	99.4
In the main text	1	0.3
As supplemental material	1	0.3
Open-source software		
No	234	72.2
Yes	12	3.7
Unclear	78	24.1
Script analysis available		
No	324	100.0
Statistical analysis plan		
No	324	100.0
Data sharing		
No	309	95.4
In Public repositories	2	0.6
Under reasonable request	13	4.0
Open peer-review		
No	316	97.5
Yes	8	2.5
Open access *		
No	203	62.7

Open Science practices	N	%
Report guideline		
Yes, in the journal	98	30.2
PubMed Central (PMC)	49	15.1
In public repositories	7	2.2
* Values exceeded the total of 324 because they may be open access in more than one format.		

In general, we observed an increase in manuscripts adopting all OSPs over time. When we considered the frequency of adoption of the most common OSPs per year, open access emerged as the first practice adopted by the manuscripts. Until 2008, only this and the utilisation of reporting guidelines had been adopted, and from 2009, the manuscripts analysed have also adopted the protocol register. Regarding other OSPs, adopting these practices has become more frequent since 2015 and is increasing (Fig. 2).

In the univariate analysis, adopting these practices was less frequent in older manuscripts. On the other hand, manuscripts from Asia presented a higher frequency of OSPs than manuscripts from Europe. Moreover, manuscripts published in journals with higher impact factors and gold or diamond open access more frequently adopted OSPs (Table 2). In the multiple analysis, more recent manuscripts and those published in journals with higher impact factors and gold or diamond open access policy presented more frequently adopted at least one OSP (Table 2).

Table 2
Logistic regression analysis to evaluate the association of explanatory variables and the adoption of at least one open Science practice in the analysed manuscripts (n = 324)

Explanatory variables	Adoption of open science practices			
	Unadjusted OR (95%CI)	p	Adjusted OR (95%CI)	p
Years since publication	0.81 (0.77 to 0.85)	< 0.001	0.80 (0.76 to 0.85)	< 0.001
Continent (ref.: Europe)	1.00		*	
Asia	1.92 (1.02 to 3.61)	0.042		
North America	0.73 (0.35 to 1.51)	0.393		
South America	1.63 (0.86 to 3.09)	0.135		
Africa	1.20 (0.34 to 4.32)	0.775		
Oceania	6.19 (0.76 to 50.36)	0.088		
Journal's Open access policy (ref.: closed or hybrid)	1.00		1.00	
Gold	3.94 (1.86 to 8.33)	< 0.001	5.88 (2.33 to 14.85)	< 0.001
Journal's Impact factor (quantitative variable)	1.21 (1.08 to 1.36)	0.001	1.41 (1.22 to 1.64)	< 0.001
* Variable not included in the adjusted model OR = Odds ratio; 95%CI = 95% Confidence interval				

When we excluded the open access and analysed the association with other OSPs, the prevalence of OSPs was 39.5% (95%CI = 34.2–45.1%). Again, we observed that adopting OSPs other than open-access was more frequent in more recent papers and those published in higher-impact factor journals. Moreover, manuscripts with the first author from South America presented twice a higher chance of adopting OSPs in the unadjusted analysis (Table 3) than manuscripts with European first authors. Nevertheless, only years since publication and the journal's impact factor were associated with adopting OSPs other than open access in the adjusted model (Table 3).

Table 3
Logistic regression analysis to evaluate the association of explanatory variables and the adoption of at least one open Science practice excluding open access in the analysed manuscripts (n = 324)

Explanatory variables	Adoption of Open science practices other than open access			
	Unadjusted OR (95%CI)	p	Unadjusted OR (95%CI)	p
Years since publication	0.74 (0.69 to 0.79)	< 0.001	0.70 (0.65 to 0.76)	< 0.001
Continent (ref.: Europe)	1.00		*	
Asia	1.77 (0.98 to 3.20)	0.058		
North America	0.89 (0.40 to 1.96)	0.766		
South America	2.23 (1.21 to 4.12)	0.010		
Africa	0.79 (0.20 to 3.11)	0.731		
Oceania	3.14 (0.84 to 11.73)	0.088		
Journal's Open access policy (ref.: closed or hybrid)	1.00		*	
Gold	1.23 (0.70 to 2.15)	0.469		
Journal's Impact factor (quantitative variable)	1.39 (1.24 to 1.57)	< 0.001	1.68 (1.43 to 1.99)	< 0.001
* Variable not included in the adjusted model OR = Odds ratio; 95%CI = 95% Confidence interval				

Finally, from the journals with more manuscripts included, we observed that only one journal recommended all OSPs according to its "Instructions for Authors" section. The journal with more papers included has recommended most of the practices. Among the OSPs, the most commonly recommended was the adherence to CONSORT to report the paper (13 out of 15 journals), followed by the use of other reporting guidelines (12 out of 15), data sharing (10 out of 15) and RCT registration (9 out of 15) (Table 4). Most journals have a hybrid route for open access, and two journals are closed regarding open access. Considering the number of items assessed per journal, the median (range) for the hybrid route journals was 4 (3 to 6) items, and for the gold route journals was 1.5 (0 to 3) items (Table 4).

Table 4
Characteristics of main journals evaluated in the “Instructions to authors” section concerning the recommendations to adopt Open Science practices

Journals	Open access policy	Protocol publication	Protocol register	CONSORT	Other report guidelines	Data sharing	Other practices	N
Caries Research	Hybrid	X	X	X	X	X		47
Journal of Dentistry	Hybrid		X	X		X		31
Journal of Dental Research	Hybrid		X	X	X			27
Clinical Oral Investigations	Hybrid	X	X	X	X	X	X	25
Community Dentistry and Oral Epidemiology	Hybrid		X	X	X	X		14
Pediatric Dentistry	Closed			X	X			11
Journal of Clinical Pediatric Dentistry	Gold					X		11
JADA	Hybrid		X	X	X	X		9
BMC Oral Health	Gold		X	X		X		8
European Archives of Paediatric Dentistry	Hybrid		X	X	X	X		7
International Journal of Paediatric Dentistry	Hybrid		X	X	X	X	X	7
Oral Health & Preventive Dentistry	Gold							6
European Journal of Oral Sciences	Hybrid			X	X	X		5
Journal of Dentistry for Children	Closed			X	X			5

Journals	Open access policy	Protocol publication	Protocol register	CONSORT	Other report guidelines	Data sharing	Other practices	N
Journal of Indian Society of Pedodontics and Preventive Dentistry	Gold			X	X			5
N = Number of manuscripts included in the study published in the journal								

The raw data used in the analysis, including the manuscripts' titles and PMIDs, can be accessed and downloaded at http://repositorio.uspdigital.usp.br/handle/item/565 [19].

Discussion

Research into effective dental caries treatments is crucial, given its significant impact on the population [1, 2]. Therefore, the efficacy of these treatments should be investigated through well-designed and conducted RCTs [5, 9]. However, ensuring transparency throughout all stages of the scientific process is essential for a more accurate assessment of the methodological quality and adherence to research integrity principles involved in these studies [10]. To achieve this standard, trials should adhere to Open Science's different practices and principles [10–12]. In this regard, our study examined the adoption of OSPs in a representative sample of RCTs related to dental caries management published in this century.

We found that approximately two-thirds of the articles adopted at least one OSP. However, considering each OSP isolated, the adherence drastically decreases to less than half of the manuscripts and is sometimes null. The most common OSP was the open access. Open access has been established since the 1990s, marked by the inception of pioneering platforms such as ArXiv.org, the Open Science Institute (later renamed to Open Science Foundations) and the Scientific Electronic Library (SciELO) in Brazil [20]. It is important to highlight that several universities have recently made it mandatory for their staff to publish open access [21], which may be reflected in our findings. Nevertheless, adopting this practice may face challenges, particularly regarding authors' financial constraints in covering article processing charges or opting for journals with higher impact factors, which commonly impose open-access fees.

In addition to open access, the other most frequently adopted OSPs were protocol registration and using a reporting guideline, mainly the CONSORT. These findings were expected since these OSPs are the most traditional ones. Similar to open access, trial registration has also become commonplace since the Food and Drug Administration Modernization Act of 1997 publication trial registration has also become prevalent since the publication of the Food and Drug Administration Modernization Act of 1997 [22] and the subsequent creation of the clinicaltrials.gov platform. This period also coincides with the conception and first version of the CONSORT guideline [23]. Both initiatives aimed to ensure transparency in the conduct and reporting of RCTs, and they gained momentum in other areas of health, including dentistry.

Corroborating the findings observed for dental journals listed in the 2021 Journal Citation Reports [24], we observed that protocol registration and use of a reporting guideline were also the most frequently endorsed by the journals with the highest frequency of RCTs in our survey. Even so, for both practices, less than half of the cariology-related RCTs published after 2000 followed either of these practices, and even in the past 5 years the proportion did not really exceed 75%. It is important to note that only the most updated versions of the authors' instructions for these journals were evaluated, which is a limitation of our study. These instructions may have adopted these recommendations recently, which may partially be linked to a more frequent adoption of OSPs by more recently published manuscripts. On the other hand, we noticed that some specific OSPs are still not yet covered, even in the most recent versions of the authors' guidelines, indicating that a particular focus should be given to them in the coming years.

Studies evaluating OSPs in other areas have found even lower frequencies for different practices compared to our sample, even considering that they evaluated more recently published manuscripts. The frequency of articles with pre-registration was about 16% in articles published in surgical journals [25], about 8% for papers on medical radiology [26] and 12% for manuscripts on sports medicine [27]. A study evaluating more than 10,000 manuscripts on dental research observed a frequency of 7% of the papers with the registered protocol. Most papers included in this previous study were published since 2005, and the evaluation of OSPs was automatised [28]. Regarding reporting guidelines, 8% [26] and 12% [27] of the papers published in radiology and sports medicine, respectively, followed guidelines to report the manuscript. However, the higher values found in our study are probably due to our focus solely on RCTs, while previous studies considered any type of study [25–27]. Indeed, guidelines for reporting RCT are pioneers in this sense [29]. In fact, a higher frequency (78%) than the one observed in our study was evidenced among interventional studies on physical activity behaviour change [30].

On the other hand, very few articles adopted other OSPs evaluated in our study. Considering data sharing, probably the OSP currently receiving the most attention, only two studies (0.6%) mentioned making data available in public repositories. However, we could not properly access the data in one of these studies [31]. In other manuscripts, the authors only stated that the data could be made available on reasonable request, which is not counted as "current" data sharing in previous studies [28, 32]. Other manuscripts also found a low prevalence of data sharing in articles published in dentistry, around 2% [28, 33]. While most dental journals have currently endorsed data sharing, adherence to this practice remains recommended for authors rather than being obligatory [24], which can justify the low prevalence of 'real' data sharing observed in the manuscripts.

Despite the low frequency of OSPs, we could observe that the chance of adopting open science practices is higher in more recent articles, corroborating previous findings [28, 33]. While the concept of open science is not novel, its momentum has notably surged in recent years, mainly driven by advancements in digital technology [20]. Therefore, this finding was anticipated. Besides, some additional findings can be addressed considering the timeline analysed. Open access had a significant increase until 2014, but after that, the frequency of its adoption remained stable. On the other hand, protocol registration and use of reporting guidelines first occurred at the end of the first decade, but both practices have shown a steeper increase until now. The adoption of OSPs other than open access, protocol registration and use of reporting guidelines is also increasing, although modestly.

Articles published in journals with a higher impact factor also showed a higher frequency of open science practices, which was also observed for journals in dentistry [34] but not in medical radiology [26]. Another variable positively associated with OSPs was the journal's open-access policy. Although this last one is also an expected finding, adopting OSPs other than open access was only associated with the year of publication and the journal's impact factor. This finding seems contradictory as open-access journals via the gold route would be expected to encourage other practices. One exception is the open peer review. Of the eight articles in which peer review was open, all were published in gold open-access journals.

When we looked at the journal recommendations, only 4 among 15 journals evaluated were gold open-access journals. Of these four journals, one did not recommend any OSP in its instructions to authors, another recommended using reporting guidelines, and another only recommended data sharing. The fourth gold open-access journal recommended registering the protocol, using the CONSORT and sharing data. However, other practices were not recommended.

These findings indicate a low frequency of OSPs, particularly for less conventional ones like open-source code and data sharing, statistical analysis plans, and open notebooks with detailed methodology. Although the discussion about these practices is relatively recent, their adoption appears to be progressing slowly. If this current upward trajectory continues, it will take approximately 20 years to ensure the majority of articles incorporate at least one of these practices. However, the increased frequency observed in the last three years suggests a potential positive shift.

Possible initiatives by researchers and journals to expedite the adoption of OSPs should be addressed. The high frequency of RCTs with prior registration and CONSORT adherence is likely mainly due to journal requirements regarding these steps. Therefore, journals should extend these requirements to other practices, such as sharing data and codes, prospective registering and publishing research protocols irrespective of their study designs, and making methodological and research conduct details available.

Similarly, funding agencies also have a fundamental role in this progress. Funded research reports should make available and public all the steps related to conducting the research, which should be demanded and audited by the grant agencies [35–37]. Moreover, different stakeholders involved in research should value these outputs related to OSPs in the evaluations and funding distribution systems [12, 37]. Also, a change in the rewarding academic system focusing more on responsible research practices, including open science [38], is necessary to adopt the investigated OSPs more widely.

The most remarkable example of the importance of open science could be seen during the COVID-19 pandemic [16, 17]. Researchers working on the diagnosis and treatment of dental caries, the oral health problem that most affects the population [1, 2], should follow suit, increasingly adhering to open science practices. This step will undoubtedly bring significant advances in the search for increasingly effective therapeutic alternatives for preventing and controlling this disease.

Conclusion

In conclusion, although the adoption of OSPs has increased in the last few years, the published dental caries-related RCTs still present an incipient adoption of these practices.

Abbreviations

OSP
Open Science Practices
RCT
Randomised Clinical Trial
CONSORT
Consolidated Standards of Reporting Trials
95%CI
95% Confidence Interval
OR
Odds Ratio
SD
Standard deviation
Scielo
Scientific Electronic Library

Declarations

Ethics approval and consent to participate

Not applicable

Consent for publication

Not applicable

Availability of data and materials

The raw data used in the analysis can be accessed and downloaded at http://repositorio.uspdigital.usp.br/handle/item/565

Competing interests

MMB is a senior editor of BMC Oral Health. The other authors declare that they have no competing interests.

Funding

CPA and JC are supported by Coordenação de Aperfeiçoamento de Pessoal de Nível Superior – Brasil (CAPES) – Finance Code 001. FMM is supported by Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP, grant # 2022/16528-3).

Authors' contributions

FMM, MSC, DPR and MMB participated in the conception and design of the study; CPA and BB collected the data; FMM and M-CDNJMH analyzed the data; JC, RAE, TP-C, MSC, M-CDNJMH, DPR, MMB and FMM

interpreted the data; CPA, JC and FMM drafted the manuscript; BB, RAE, TP-C, MSC, M-CDNJMH, DPR and MMB revising the manuscript critically for important intellectual content; all authors read and gave the final approval of the version to be published; all authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Acknowledgements

Not applicable

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Figures

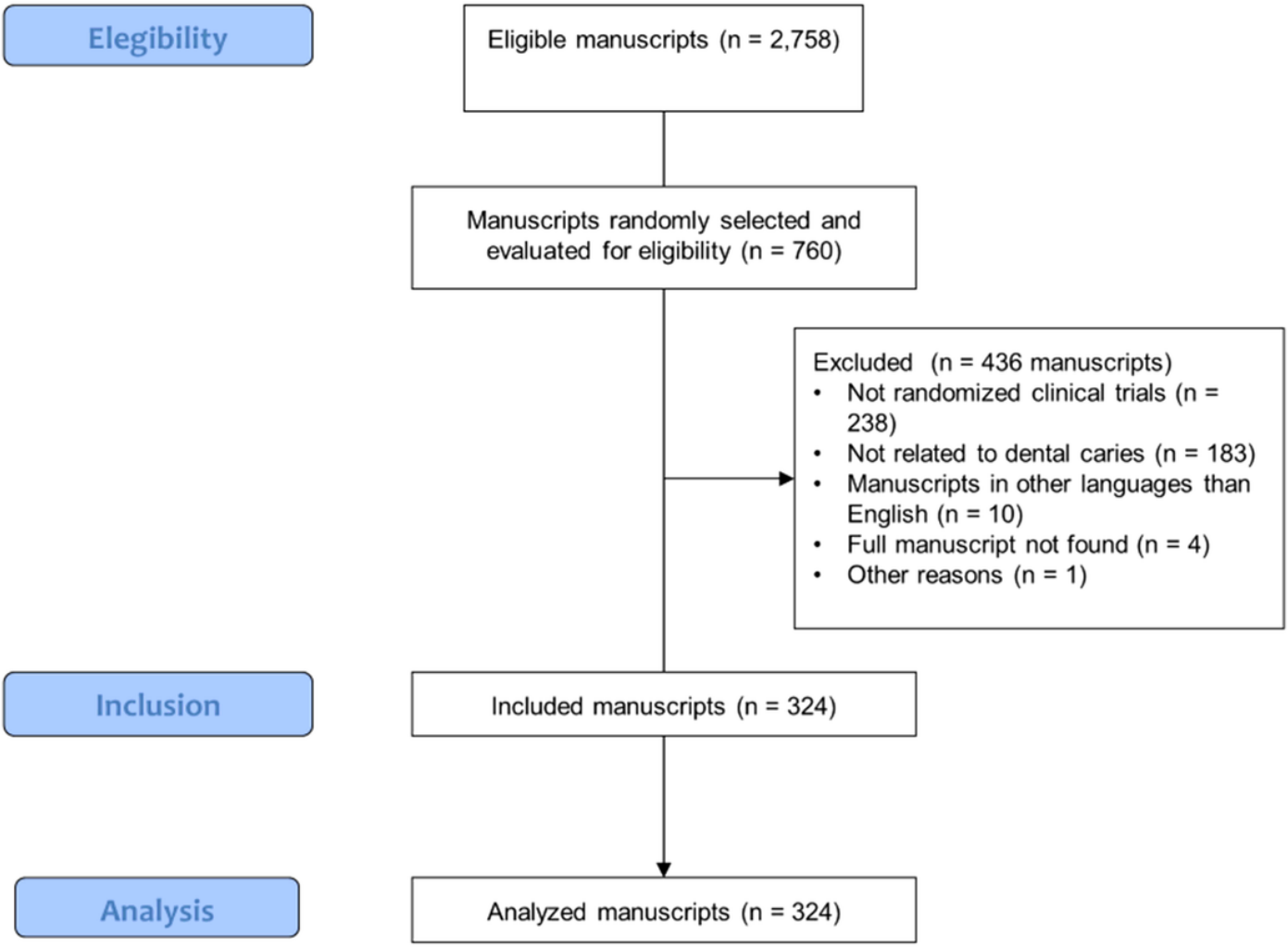

Figure 1

Flow chart presenting the number of manuscripts evaluated for eligibility included and analysed

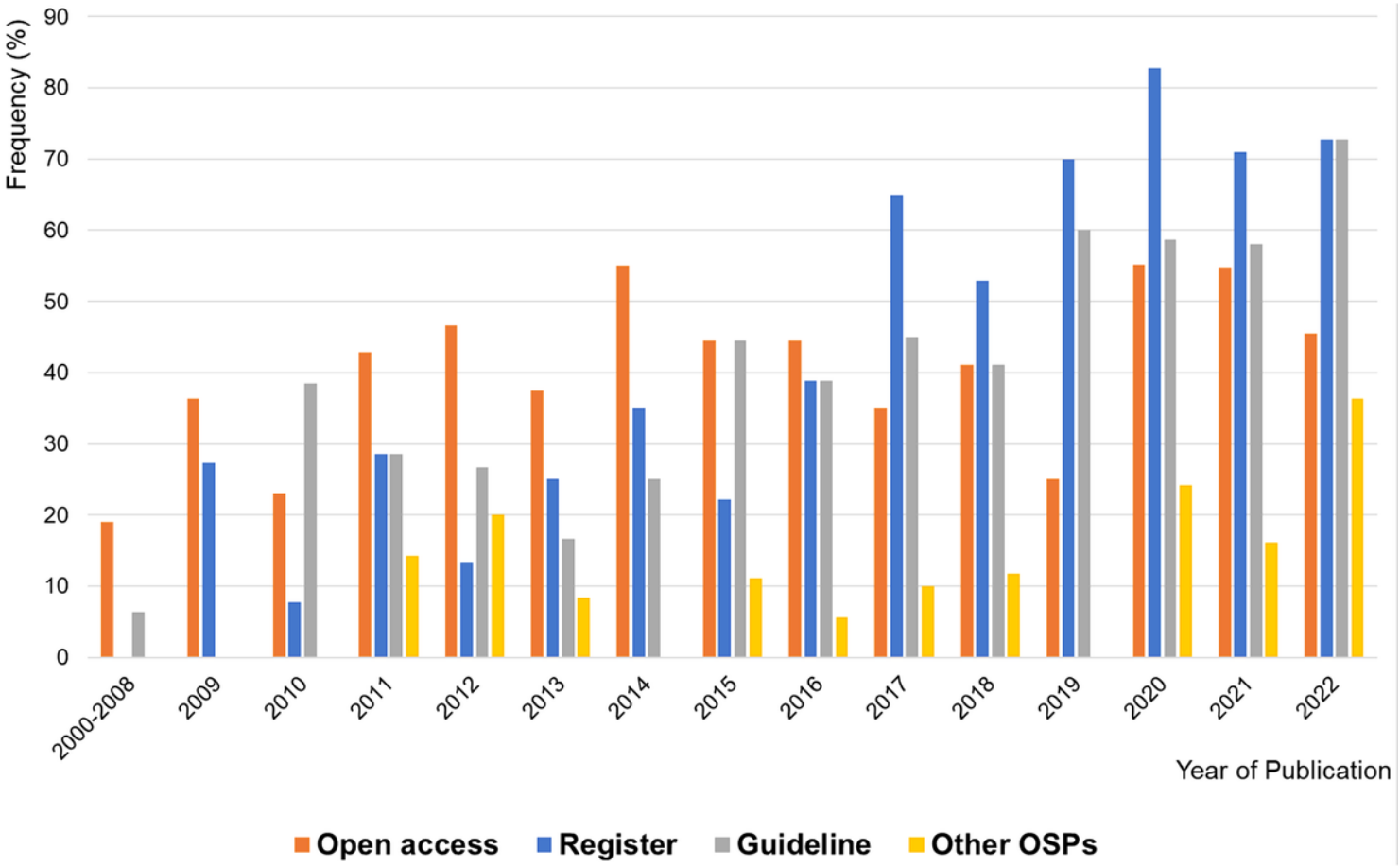

Figure 2

Frequency of adoption of Open Science Practices (OSPs) per year of study publication

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- PRISMA2020checklist.pdf