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Makou, Olga ; Eliades, Theodore ; Koletsi, Despina

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Reporting, Interpretation and Extrapolation (SPIN) in abstracts of orthodontic meta-analyses published from 2000 to 2020.

Olga Makou[1], Theodore Eliades[2], Despina Koletsi[2]

[1] Dentistry Department, Cardenal Herrera University of Valencia, Valencia, Spain

[2] Clinic of Orthodontics and Pediatric Dentistry, Center of Dental Medicine, University of Zurich, Switzerland

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Short title: *SPIN* in orthodontic meta-analyses

Correspondence: Dr. Despina Koletsi, Plattenstrasse 11, Zurich, CH-8032. Email: d.koletsi@gmail.com/ despoina.koletsi@zzm.uzh.ch

Summary

Aim: To assess the prevalence of and identify factors associated with SPIN in abstracts of orthodontic meta-analyses.

Materials and Methods: Electronic search was performed within the contents of 5 orthodontic journals and the Cochrane Database of Systematic Reviews (CDSR) to identify meta-analyses of studies involving humans, from January 1st, 2000 until August 31st 2020. Inclusion of SPIN in the abstract of meta-analyses, defined as misleading reporting, misleading interpretation and inappropriate extrapolation of the findings, was documented. Extent of SPIN and associations with journal and year of publication, type of study, number of authors, continent of authorship, methodologist involvement, funding and significance of the primary outcome were investigated.

Results: One hundred and nine meta-analyses were identified, with the highest proportion being published in the European Journal of Orthodontics (EJO: 31/109; 28.4%). Inclusion of SPIN, in at least one domain, was recorded in nearly half (53/109; 48.6%) of the studies, of which 30 (56.6%) included 2 or more domains of SPIN. Meta-analyses of observational studies presented 1.66 times higher risk for including SPIN in their abstracts compared to interventional ones (95%CIs: 1.14, 2.40; p=0.007), after adjusting for a number of predictors. Studies with a large number of authors (≥6) presented 1.76 times higher risk of SPIN (≥ 6 vs 1-3: 95%CIs: 1.04, 2.97; Wald test, p=0.021), conditional on the predefined predictors.

Conclusions: Flaws in the reporting and interpretation of the findings of abstracts of meta-analyses, as framed by inclusion of SPIN are persistent in orthodontic research, being more prevalent in meta-analyses of observational studies. Consistent, multidirectional efforts should be endorsed to improve the quality of the disseminated research findings.

Keywords: SPIN, reporting, meta-analysis, systematic review, orthodontic

Introduction

Systematic reviews (SRs) and meta-analyses have long been considered the cornerstone of evidence based research methodology with direct implications for clinical practice and clinical decision making (1). It is therefore evident that the validity and quality of their standing reflects on how stakeholders, methodologists, researchers and clinicians translate their findings for the benefit of the patients.

Notwithstanding the theoretically topmost position of meta-analyses in the evidence pyramid in biomedical sciences, these designs are not immune to methodological flaws and bias in reporting, interpretation and extrapolation of their findings (2). Likewise, dental and orthodontic published research is affected. Empirical studies in dentistry and orthodontics have elucidated the shortcomings and limitations in the conduct and reporting of systematic reviews and meta-analyses. Deficiencies to a number of quality criteria have been recognized for systematic reviews in core and high impact clinical journals in medicine (3). The problem is endemic also in oral health and orthodontic research, in various aspects and extents (4, 5).

An additional source of suboptimal reporting, interpretation and extrapolation within published research is called “SPIN”. This is related to how authors of an article, provide interpretation of the research findings, or otherwise if and on what extent, manipulate reporting to mislead the readership, either deliberately or not (6, 7). To our knowledge, a historic, first use of the term SPIN, belongs to Horton in 1995, where he described the term as “the conscious or unconscious tricks of authorial rhetoric” (8). This is exceptionally important for randomized controlled trials (RCTs), but also for systematic reviews and meta- analyses, in view of their utilization and value in the grounds of evidence quality. In essence, SPIN facilitates potentially flawed translation of research findings, thus impacting validity and accuracy in the process of knowledge accumulation by colleagues, researchers and most importantly clinicians, who apply knowledge to clinical practice.

SPIN, following other reporting deficiencies within abstracts of publications (5, 9), has been identified as an important risk factor for the validity of abstract reporting and integrity in RCTs of medical journals indexed in PubMed in 2006, with a span of approximately 37 to 58 percent encompassing suboptimal and/ or distorted presentation (6). Although SPIN has been well recognized in biomedical research for some years (6), its effect on oral health related interventions and conditions has not been assessed until very recently (10, 11). Nevertheless, there is currently no report on any study design stemming exclusively from orthodontic published research and most importantly form the leading assets of the evidence pyramid, as formulated by reports of meta-analyses.

Therefore, the aim of this study was to assess abstracts of meta-analyses published in orthodontic journals and the Cochrane Database of Systematic Reviews (CDSR), with regard to the identification, extent and associations of SPIN in published orthodontic literature from 2000 to 2020.

Materials and Methods

Search Strategy

Contents of 5 major orthodontic journals, as well as Reviews from the CDSR, were electronically searched for systematic reviews including at least one meta-analysis from January 1st, 2000 until August 31st 2020. The journals were the *American Journal of Orthodontics and Dentofacial Orthopedics (AJODO)*, *Angle Orthodontist (AO), European Journal of Orthodontics (EJO), Journal of Orthodontics (JO)* and *Orthodontics and Craniofacial Research,* as well as the CDSR covering orthodontic literature. Only the latest update of each included Review from the CDSR was considered, to avoid duplication and data correlation. The selection of the journals was based on previous research in the field (12), and relative frequency of publication of systematic reviews within, allied to expert-based decision.

Screening and Eligibility Criteria

The process involved a first stage of identification of the term “systematic review” in the titles or abstracts of the journal contents or if it was evident within the abstract that a systematic review process was undertaken. Full texts for all potentially relevant reviews were obtained to identify eligible ones. Only reviews involving humans, including studies either interventional or observational in design were eligible. Diagnostic SRs, or SRs of animal or in- vitro studies were excluded. Complex designs, such as network meta- analyses or reviews following Bayesian statistical methodology were also excluded due to the potentially different requirements in reporting and inference formulation. At a second stage, a screening within the systematic review was performed to identify reports with a quantitative synthesis of at least two studies. Screening was done independently and in duplicate, by two authors (OM, DK) and any disagreements were settled after mutual discussion or with a third investigator (TE). Exclusion criteria were applied with regard to review design.

Data Extraction

Detailed information on specific domains of the meta-analyses was extracted, again independently and in duplicate by two reviewers after initial calibration, as follows:

- Characteristics of the meta-analysis: journal of publication, publication year, continent of authorship as indicated by the first author's affiliation details, number of authors, involvement of methodologist, type of studies included in the SR (interventional, observational), funding, orthodontic related topic. Specifically for the involvement of a methodologist, ratings were based on affiliation information within the articles. For example, affiliation with a department/ unit of biostatistics, epidemiology, research methodology, was ultimately considered as indicative of such an involvement. In addition, funding information was based merely on article information, without further investigation on sources of funding.
- Information on meta-analysis level: number of studies within the primary synthesis, number of quantitative syntheses (meta-analyses) within the SR, significance or not of the primary outcome
- Assessment of SPIN: allied to the latest classification of SPIN in abstracts of systematic reviews and meta-analyses, developed by Yavchitz and collaborators in 2016 (13). This classification scheme encompassed a 3- domain assessment, pertaining to: 1. misleading reporting, 2. misleading interpretation, 3. inappropriate extrapolation in abstracts. In summary, assessment categories included areas of misleading practices which may be

applicable for any manuscript design, but also specific fields for systematic review and meta-analysis designs. Table 1 gives an overview of the examined fields. In summary, misleading reporting pertained to overemphasis or selective reporting of efficacy/ safety outcomes for the intervention group (compared to control), failure to report direction of the effect or the actual number of contributing studies/ patients to the analysis. Misleading interpretation, related to inadequate focus on p- values instead of the magnitude of effect estimates, formulation of recommendations for practice not supported by evidence, or conclusions claiming beneficial effect, while disregarding, risk of bias, heterogeneity, primary study design and reporting bias. Last, SPIN in extrapolation concerned flawed generalizability strategies to different populations or interventions.

Statistical Analysis

Descriptive statistics on the characteristics of the included meta-analyses were undertaken, supported by cross- tabulations conducted to investigate the association between the presence of SPIN and study characteristics. Prevalence and extent of SPIN was also recorded based on descriptive analyses about magnitude (1 or more types/ domains) of SPIN and exact type of misleading reporting, interpretation and extrapolation. Univariable and multivariable modified Poisson regression with robust standard errors was performed to assess the effect of study characteristics including journal of publication, year, continent of authorship, number of authors, inclusion of a methodologist, funding, study design, and statistical significance of primary outcomes on overall presence of SPIN. All potential predictors were retained in the final multivariable model. Effect modification between journal and year was checked through likelihood ratio test. Model fit was checked through Pearson goodness of fit test. The chi- square test for trend was performed to identify any trend of inclusion of SPIN across the years. The unweighted kappa statistic was used to assess inter-rater agreement for the primary outcome (ie, SPIN presence) in 15 percent of the included records, following initial calibration in 10 percent of the sample. Level of statistical significance was set at $p<0.05$ (two- sided). All statistical analyses were conducted with Stata version 15.1 software (Stata Corporation, College Station, Tx, USA).

Results

A total of 322 systematic reviews of any type were initially identified over the years 2000 to August 31st, 2020. After applying eligibility criteria, 109 meta- analyses formed the final sample (Figure 1). Reliability assessment between the investigators yielded an unweighted kappa statistic of 0.883 (95% CI: 0.661- 1.000), indicating very good agreement in the evaluation of the outcome. The highest percentage of meta-analyses were published over the last five years (Figure 2), since 2016 (65/109; 59.6%), while the EJO predominated in the percentage of published meta-analyses over the years (31/109; 28.4%), followed by the AJODO (27/109; 24.8%). Likewise, most articles originated from Europe (63/ 109; 57.8%), did not involve a methodologist/ statistician (90/ 109; 82.6%), were co- authored by 4 to 5 scientists (47/109; 43.1%), while they did not receive any funding for the completion of the study (83/109; 76.1%). The review design was mostly framed for interventional studies (79/109; 72.5%), while also claimed significance based on the results for the primary outcome of interest (81/109; 74.3%) (Table2). A median number of 5 studies was included in each meta-analysis for the primary outcome within the SRs (interquartile range IQR: 5), while the median number of quantitative syntheses included in a single SR was 4 (IQR= 4).

Fifty three of the meta- analyses (48.6%) included SPIN in either reporting, interpretation or extrapolation of the presentation of their findings in their abstracts (Table 1). The CDSR presented the fewest number of studies affected by SPIN (2/14; 14.3%), whilst the majority of studies in the AJODO and the ANGLE included SPIN in their abstracts (17/27; 63.0% and 12/17; 70.6% respectively). Study design pertaining to observational was most likely to include SPIN (21/30; 70%), while this was also the case for meta-analyses with statistically significant primary findings (44/81; 48.6%) (Table 2).

There was a wide range of topics addressed by the unity of the meta-analyses included, which were broadly schemed under 15 categories. Treatment of Class II malocclusion (17/109; 15.6%) and biomechanics related topics were the most represented (21/109; 19.3%) (Table 3). Breakdown of orthodontic topics in relation to SPIN, as well as according to study design is presented in Table 3 and Figure 3.

SPIN, in the abstract, was found solely in one domain in 23 out of 53 meta-analyses (43.4%), whilst over half (30/53; 56.6%) had SPIN in 2 or more domains, with SPIN in 2 domains being the most prevalent finding (17/30; 56.7%). Table 4 delineates the domains/ types of SPIN across affected meta-analyses in terms of misleading reporting, interpretation and inappropriate extrapolation. Failure to report the number of studies and patients actually contributing to the meta-analysis of the main outcome was the most commonly identified type of SPIN related to reporting and was present in 36 out of 53 affected reports (67.9%). Similarly, in 27/ 53 (50.9%) meta-analyses, the interpretation and conclusions related to the effect of the treatment or exposure disregarded the presence of high heterogeneity of the included primary studies. Working examples of the most prevalent domains of SPIN identified are shown in Table 5.

Multivariable modified Poisson regression did not reveal evidence of association between inclusion of SPIN in the abstract of meta-analyses and type of journal (overall Wald test, p=0.222). Epidemiologic- type meta- analyses (including observational studies) presented 1.66 times higher risk for including SPIN in their abstracts compared to interventional ones (95%CIs: 1.14, 2.40; p=0.007), conditional on journal and year of publication, continent of authorship, number of authors, involvement of a methodologist, funding information and statistical significance of the outcome of interest. In addition, inclusion of a large number of authors (≥ 6) was associated with 1.76 times higher risk of SPIN (≥ 6 vs 1-3: Relative Risk RR: 1.76; 95%CIs: 1.04, 2.97), while this was not the case for 4-5 scientists in the authorlist (4-5 vs 1-3: RR: 1.00; 95%CI: 0.60, 1.67), with an overall Wald test, p=0.021 and after adjusting for all other pre-defined predictors (Table 6). No evidence of effect modification for journal and year was detected (likelihood ratio test, p=0.321), or indication for trend in inclusion of SPIN over time (p=0.206).

Discussion

Prior Research

Orchestrated efforts to facilitate research transparency and integrity in oral health and orthodontic research have been well- documented during the last decade (14, 15). Reporting guidelines already exist for various article types, but most importantly for RCTs and systematic reviews, as represented by COSORT and PRISMA frameworks; these, have set the minimum level of required recommendations to be followed to facilitate completeness and transparency of disseminated research, with clinically relevant implications. However, inadequate reporting impacting on disseminated knowledge towards students, clinicians and scientists is persisting, and this has been confirmed by the findings of the present study. Evidence of suboptimal and potentially misleading reporting and interpretation of the results from abstracts of meta-analyses of orthodontic research, which span a range of 20 years has been detected. In this respect, guidance from the PRISMA statement along with checklist for abstracts (16) may be considered limited on the interpretation of results from multiple outcomes, pertaining to simultaneous assessment of biases directly related to primary studies included in meta-analyses, or heterogeneity. The problem is further augmented, when an a priori set or pre- registration of a systematic review has not been considered, thus allowing for selective prioritization of reporting or interpretation of outcomes/ interventions allied to the review authors' preferences (13).

To our knowledge, this is the first study on the assessment of SPIN in orthodontic research and evidently in systematic reviews/ meta-analyses in dentistry. Previous studies in biomedical literature have elucidated the presence and effect of SPIN in both abstracts and main texts of published manuscripts. With regard to the prevalence of the condition in abstracts of systematic reviews, our findings are in agreement with previous reports (13). A total of 39 types of SPIN have been documented across different types of published designs/ reports in biomedical research, while 21 have been found applicable for abstracts with more than half being inbred to systematic reviews (13). Prevalence of SPIN in abstracts of non- randomized studies of interventions has also appeared exceptionally high, with more than 80 percent including at least one domain of SPIN (17). This has also been confirmed by most recent reports and abstracts of presumably higher quality RCTs, published in top- rank specialty journals, albeit in a lower preponderance (18).

Interestingly, dental research is not immune to this type of reporting and interpretation flaw. In a small empirical study assessing 47 dental RCTs with statistically non- significant results and pertaining to a wide spectrum of specialties related to oral health, more than half of the studies incorporated at least one domain of SPIN in the main text, while abstracts accounted for 61.7 percent of this condition. The most prevalent domain of SPIN in both main text and abstract related to selective focus, on part of the authors, on identified outcomes with statistically significant findings, other than the primary one (11). No further insights on specialty specific related SPIN are provided in this study. Furthermore, earlier (10) as well as more recent reports (19) of abstracts of RCTs in dentistry and periodontology/ oral implantology has revealed a high frequency of inclusion of SPIN in the results, but mostly in the conclusions section of the abstract, pertaining to 30 to 60 percent. There are currently no published reports related to the assessment of SPIN in orthodontic research per se; however, a protocol for identification of SPIN related to adverse effects described in abstracts of systematic reviews of orthodontic interventions has lately emerged, with an initiative to identify SPIN effects that might potentially mislead readership and misguide clinical practice (20).

Findings in context

SPIN- type identified by the present empirical study, was mostly included in the reporting and interpretation of the results of the meta-analyses assessed. The former pertained mainly to disregarding of the actual number of units, either patients or studies, in the presentation of the results in the abstract; the former included failure to consider risk of bias and heterogeneity in the interpretation of potentially beneficial effects of the treatment/ association under study. Such findings are in keeping with previously exposed shortcomings in the quality of the published research in dentistry and orthodontics (2, 21-24), although actions have been endorsed to improve quality of reporting by journals and editors (15).

Detection of SPIN in systematic reviews of observational research was apparently identified as more prevalent. Observational study design has been considered as offering lower quality evidence as a rough rule, while also being more prone to several types of biases (25). Observational- type studies have been in the spotlight as well, for being susceptible to other types of methodological or statistical limitations both contributing to compromised publication reports, yielding potential misinterpretations or misguidance to the readership (26, 27). In this respect, it might have been possible that authors of meta-analyses of observational studies are less likely to acknowledge and report findings in their abstracts, allied with the state of the evidence, bias or heterogeneity issues that might be present. Inclusion of authorship characteristics in our recordings and analyses were based on prior research in the field, in an attempt to highlight any potential association with SPIN (28). Furthermore, identification of increased risk of SPIN inclusion in abstracts of meta-analyses with joint co-authorship of six or more authors might be indicative of a potential complex structure and research question addressed in these reviews. However, one might argue that for limited scale reviews, such as ones mostly identified in dental research, in contradiction to systematic reviews and meta-analyses in medicine, a pertinent number of up to 5 co-authors might suffice. Further inclusion of co-authors, which would translate to unjustified breakdown of research work among the investigators, as a best- case scenario, or even honorary, not to mention ghost authorship, should be eliminated (29, 30). Accountability and transparency should inform reporting and accurate inferences for clinical practice. A recent study on authorship characteristics identified a number of three to five authors in orthodontic meta-analyses as the most prevalent pattern (28). Although no formal assessment of associations could be sought for different orthodontic topics and inclusion of SPIN, due to the wide range of thematology identified, domains such as alternative tooth movement strategies, cross-bite treatment, use of implants and oral hygiene techniques were mostly related to SPIN inclusion. This might reflect a potential uncertainty on how to evaluate and interpret evidence form contemporary and modern orthodontic techniques, however, further insights might only be speculative, in view of the low absolute number of reviews included in specific thematic domains.

The present empirical study evaluated SPIN prevalence in abstracts of systematic reviews including study syntheses. It might be argued that abstract is only a small part of the review, while also word count limits might be accountable for the identified findings. Notwithstanding, abstracts of published research have long been considered the backbone of research translation to clinical practice, as most frequently, this is the only research part of an article accessed and/ or assessed by end-users, healthcare consumers and clinicians (31, 32). Specific guidelines have been developed for the reporting of abstracts of systematic reviews (33), facilitating transparency, integrity and a more focused guidance to authors. Journals and editors have endorsed policies for more extensive and structured abstract formats specifically designed for systematic review articles with word limits over 250 and extending up to 350 words, or more lenient guidelines (34, 35); authors should also be encouraged to consistently report vital elements of the review process and interpretation of their findings framed within the appropriate context.

Limitations

The study is not free of limitations. Evidently so, we did not assess any orthodontic related meta-analysis published across the range of publications channels, platforms and databases; nevertheless, the inclusion of 5 most prominent orthodontic journals and systematic reviews from the CDRS, over the last 20 years may be considered fairly representative within the orthodontic specialty, while previous empirical studies have also adopted similar search strategies (12, 36). Only reviews with inclusion of at least one meta-analysis were ultimately assessed, thus, offering an apparently decreased sample size, in view of the larger pool of the existent systematic reviews. In this respect, if reports with no formal assessment of pooled effects were considered, it would not have been possible to evaluate aspects of SPIN pertaining to translation and interpretation of pooled data within the context of homogeneity, effect estimates, p-values and direction of the effect after data synthesis. Additionally, more complex designs such as network meta-analyses, or meta-analyses using Bayesian methodologies instead of frequentist, were not considered; inclusion of the latter might have complicated the classification process, since they follow different statistical inferences for hypothesis testing, or exploration of heterogeneity and incoherence aspects, which are not directly related to how standard meta-analyses are interpreted and reported (37, 38). In essence, only 2 such examples were identified in the initially identified large pool of reviews and were ultimately excluded. In addition, recording of variables such as involvement of a methodologist, or determination of the continent of authorship might have imposed some risk for misclassification. The former has been based solely on information provided regarding the affiliation of the authors, while for the latter, the affiliation of the first- listed author was assessed, as it was considered the most representative of where the bulk of the work has been conducted.

Nevertheless, other acceptable options might have been the assessment or the corresponding or senior authors, or a combination of approaches. Moreover, coexistence of SPIN within abstracts as well as full- texts of meta-analyses was not assessed, however, previous research is strongly supportive of commonly identified patterns of high SPIN prevalence within the full- length reports (13).

Conclusion

The development of evidence based practices in orthodontic research has been well- represented by a sharp increase in the number of meta-analyses in the field, however, reporting practices remain suboptimal. Inclusion of SPIN in abstracts of orthodontic meta-analyses is prevalent and associated mostly with observational research. Consistent efforts should be endorsed by stakeholders, editors, journals, reviewers and authors to raise awareness and improve adherence to more concise, transparent and optimal reporting and interpretation strategies, within and beyond the community.

Conflict of Interest

Nothing to declare

Ethical Approval

Not required. This is a meta-epidemiologic study without patients or records involvement

Data Availability

The data underlying this article will be shared on reasonable request to the corresponding author

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Captions

Table 1. Overview of domain classification in abstracts of meta-analyses (according to Yavchitz et al 2016).

Table 2. Frequency distribution for the presence of SPIN or otherwise, by article characteristic (n=109).

Table 3. Prevalence of SPIN across orthodontic topic domain, by type of study design.

Table 4. Domain and extent of SPIN across affected meta-analyses (n=53).

Table 5. Working examples of the most prevalent types of SPIN identified within the assessed meta-analyses.

Table 6. Univariable and multivariable modified Poisson regression with robust standard errors and associated Relative Risks (RRs) with respective 95% Confidence Intervals (CIs) for the effect of a range of article characteristics on inclusion of SPIN in abstracts of orthodontic meta-analyses (n=109).

Figure 1. Study selection process

Figure 2. Frequency distribution of published meta- analyses across the years 2000 to 2020, by presence of SPIN

Figure 3. Horizontal bar graph of frequency distribution of the identified orthodontic topics, by presence of SPIN.

Table 1. Overview of domain classification in abstracts of meta-analyses (according to Yavchitz et al 2016).

Misleading Reporting	**Misleading Interpretation**	**Inappropriate Extrapolation**
Selective reporting/ overemphasis on beneficial/ safety outcomes of intervention	Title suggesting beneficial effect not supported by findings	Conclusions extrapolating review's findings to a different population
Failure to report wide CI	Overreliance on p-values	Conclusions extrapolating review's findings to a different intervention
Hide COI	Focus on relative effect when absolute is small	Conclusions extrapolating review's findings from a surrogate marker or a specific outcome to the global improvement of the disease
Inadequate focus on results of primary studies favoring intervention, instead of meta-analysis	Conclusion claiming equivalence/ safety for non-significant results with wide CIs	
Focus selectively on statistically significant efficacy outcome	Providing recommendations not supported by findings	
Failure to report number of studies/ patients contributing to meta-analysis	Conclusions claiming beneficial effect disregarding high RoB in primary studies	
Failure to specify direction of effect if favoring control	Conclusions claiming beneficial effect disregarding reporting bias	
	Conclusions claiming beneficial effect despite high heterogeneity	
	Ignoring of inclusion of different study designs in the synthesis (ie, trials, observational studies)	

CI, confidence interval; COI, conflict of interest; RoB, risk of bias

Table 2. Frequency distribution for the presence of SPIN or otherwise, by article characteristic (n=109).

	Presence of SPIN in abstracts of orthodontic meta-analyses		
	No N (%)	**Yes N (%)**	**Total N (%)**
Year of publication			
2000- 2015	21 (47.7)	23 (52.3)	44 (100.0)
2016- 2020	35 (53.9)	30 (46.1)	65 (100.0)
Journal			
CDSR	12 (85.7)	2 (14.3)	14 (100.0)
AJODO	10 (37.0)	17 (63.0)	27 (100.0)
ANGLE	5 (29.4)	12 (70.6)	17 (100.0)
EJO	17 (54.8)	14 (45.2)	31 (100.0)
OCR	9 (56.3)	7 (43.7)	16 (100.0)
JO	3 (75.0)	1 (25.0)	4 (100.0)
Continent			
America	8 (44.4)	10 (55.6)	18 (100.0)
Europe	37 (58.7)	26 (41.3)	63 (100.0)
Other	11 (39.3)	17 (60.7)	28 (100.0)
No. authors			
1- 3	16 (53.3)	14 (46.7)	30 (100.0)
4- 5	29 (61.7)	18 (38.3)	47 (100.0)
≥ 6	11 (34.4)	21 (65.6)	32 (100.0)
Methodologist Involvement			
No	43 (47.8)	47 (52.2)	90 (100.0)
Yes	13 (68.4)	6 (31.6)	19 (100.0)
Funding			
No	43 (51.8)	40 (48.2)	83 (100.0)
Yes	13 (50.0)	13 (50.0)	26 (100.0)
Type of Study			
Interventional	47 (59.5)	32 (40.5)	79 (100.0)
Observational	9 (30.0)	21 (70.0)	30 (100.0)
Significance			
No	19 (67.9)	9 (32.1)	28 (100.0)
Yes	37 (45.7)	44 (54.3)	81 (100.0)
Total	56 (51.4)	53 (48.6)	109 (100.0)

Table 3. Prevalence of SPIN across orthodontic topic domain, by type of study design.

	Presence of SPIN in abstracts of orthodontic meta-analyses				
Orthodontic Topic	**Interventional**	**Observational**	**Interventional**	**Observational**	
	No N_{total} **(%)**		**Yes** N_{total} **(%)**		**Total N**
Adverse events[1]	4	0	2	1	
	4 (57.1)		3 (42.9)		7
Alternative tooth movement[2]	2	0	3	1	
	2 (33.3)		4 (66.7)		6
Biomechanics	9	5	6	1	
	14 (66.7)		7 (33.3)		21
Bonding	5	0	0	0	
	5 (100.0)		0 (0.0)		5
Class II treatment strategies	8	1	6	2	
	9 (52.9)		8 (47.1)		17
Class III treatment strategies	5	0	2	0	
	5 (71.4)		2 (28.6)		7
Cleft	0	0	1	1	
	0 (0.0)		2 (100.0)		2
Crossbite treatment	1	1	3	1	
	2 (33.3)		4 (66.7)		6
Dental anomalies/ malocclusion	0	0	0	6	
	0 (0.0)		6 (100.0)		6
Impacted canines	2	0	1	0	
	2 (66.7)		1 (33.3)		3
Implants	3	0	3	2	
	3 (37.5)		5 (62.5)		8
Open-bite treatment	3	0	1	1	
	3 (60.0)		2 (40.0)		5
Oral hygiene	4	0	4	3	
	4 (36.4)		7 (63.6)		11
Quality of life	0	2	0	2	
	2 (50.0)		2 (50.0)		4
Retention	1	0	0	0	
	1 (100.0)		0 (0.0)		1

[1] includes pain, root resorption; [2] includes orthognathic surgery, surgically assisted tooth movement

Table 4. Domain and extent of SPIN across affected meta-analyses (n=53).

	Reporting N (%)	**Interpretation N (%)**	**Extrapolation N (%)**
Selective reporting/ overemphasis on efficacy outcomes favoring intervention	1 (1.9)		
Inadequate focus on results of primary studies instead of those from meta-analyses	2 (3.8)		
Conclusion focusing selectively on statistically significant outcome	1 (1.9)		
Failure to report number of studies/ patients actually contributing to meta-analysis for main outcomes	36 (67.9)		
Failure to specify the direction of the effect when favoring the control	2 (3.8)		
Inadequate focus on p- value instead of magnitude of effect estimates		9 (17.0)	
Conclusions claiming beneficial effect despite high RoB in primary studies		19 (35.8)	
Conclusions claiming beneficial effect despite high heterogeneity		27 (50.9)	
Ignoring that the review included different study design		4 (7.5)	
Conclusion extrapolating review findings to different intervention			1 (1.9)

Table 5. Working examples of the most prevalent types of SPIN identified within the assessed meta-analyses.

Type of *spin*	**Example**
Failure to report number of studies/ patients actually contributing to meta-analysis for main outcomes	24 studies included in the review, while only 3 contributed to meta-analysis of the specified outcome/ albeit no reporting: *"Relative to pretreatment, the condition-specific OHRQoL was significantly improved 6 months after surgery, particularly in the perceptions to social aspects (mean difference [MD] 4.88, 95% confidence interval [CI] 2.45 to 7.32)"*
Inadequate focus on p- value instead of magnitude of effect estimates and CIs	*"On average, temporary intraoral skeletal anchorage devices (TISADs) enabled more anchorage preservation than did conventional methods (P<0.001)"*
Conclusions/ Interpretation claiming beneficial effect despite high RoB in primary studies	No consideration of the risk of bias of included primary studies, although high RoB studies identified: *" The results showed that chincup therapy decreased SNB angle and increased ANB angle; the total pooled weighted mean difference values (95% confidence interval) were -1.18 (-0.69, -0.67; P<.00001) and 1.90 (0.60, 3.21; P=.004), respectively."*
Conclusions/ Interpretation claiming beneficial effect despite high heterogeneity	No consideration of heterogeneity between included primary studies, although substantial levels were inspected: *"The results of the meta-analysis showed that temporary intraoral skeletal anchorage devices (TISADs) are more effective than conventional methods of anchorage reinforcement. … seems not only statistically but also clinically significant"*

CI, confidence interval

Table 6. Univariable and multivariable modified Poisson regression with robust standard errors and associated Relative Risks (RRs) with respective 95% Confidence Intervals (CIs) for the effect of a range of article characteristics on inclusion of SPIN in abstracts of orthodontic meta-analyses (n=109).

Category	**Univariable**			**Multivariable**		
	RR	**95% CI**	**p-value**	**RR**	**95% CI**	**p-value**
Year	Per unit		0.178			0.132
	0.97	0.92, 1.02		0.96	0.92, 1.01	
Journal			0.045*			0.222*
CDSR	Reference			Reference		
AJODO	4.41	1.18, 16.52	0.028	3.04	0.74, 12.59	0.124
ANGLE	4.94	1.31, 18.60	0.018	3.40	0.77, 14.92	0.106
EJO	3.16	0.82, 12.15	0.094	2.47	0.54, 11.34	0.246
Other (OCR/ JO)	2.80	0.69, 11.32	0.149	2.17	0.47, 10.17	0.324
Continent			0.180*			0.998*
America	Reference			Reference		
Europe	0.74	0.45, 1.24	0.253	0.99	0.62, 1.57	0.950
Other	1.09	0.66, 1.82	0.734	1.00	0.61, 1.63	0.989
No. Authors			0.044*			0.021*
1-3	Reference			Reference		
4-5	0.82	0.48, 1.39	0.465	1.00	0.60, 1.67	0.991
≥ 6	1.41	0.89, 2.23	0.146	1.76	1.04, 2.97	0.034
Methodologist			0.155			0.249
No	Reference			Reference		
Yes	0.60	0.30, 1.21		0.69	0.36, 1.30	
Funding			0.872			0.899
No	Reference			Reference		
Yes	1.04	0.66, 1.62		1.03	0.69, 1.54	
Study Category			0.003			0.007
Interventional	Reference			Reference		
Observational	1.73	1.21, 2.47		1.66	1.14, 2.40	
Significance			0.075			0.133
No	Reference			Reference		

Yes	1.69	0.95, 3.01		1.57	0.87, 2.82	

*wald test for overall association

Figure 1

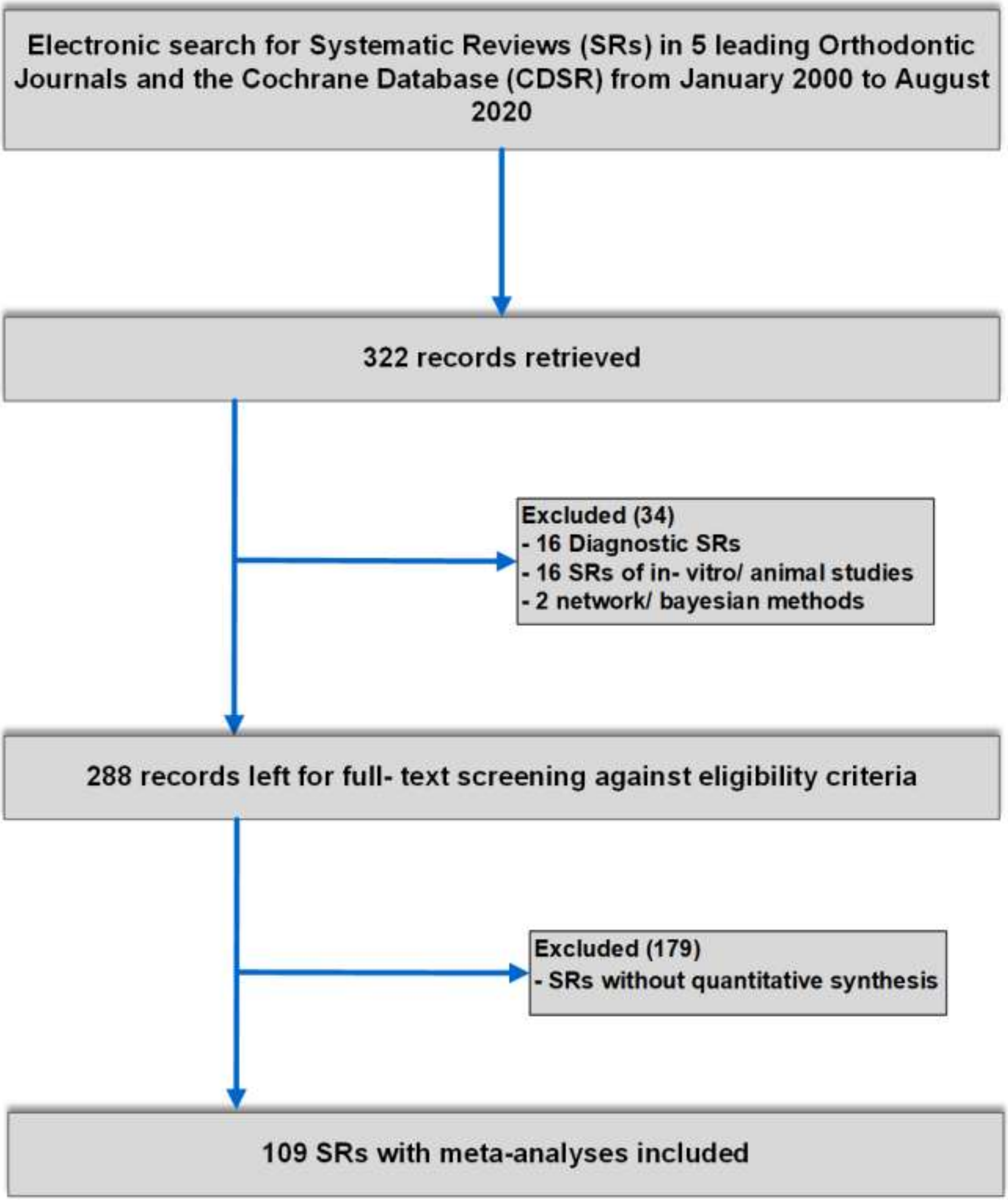
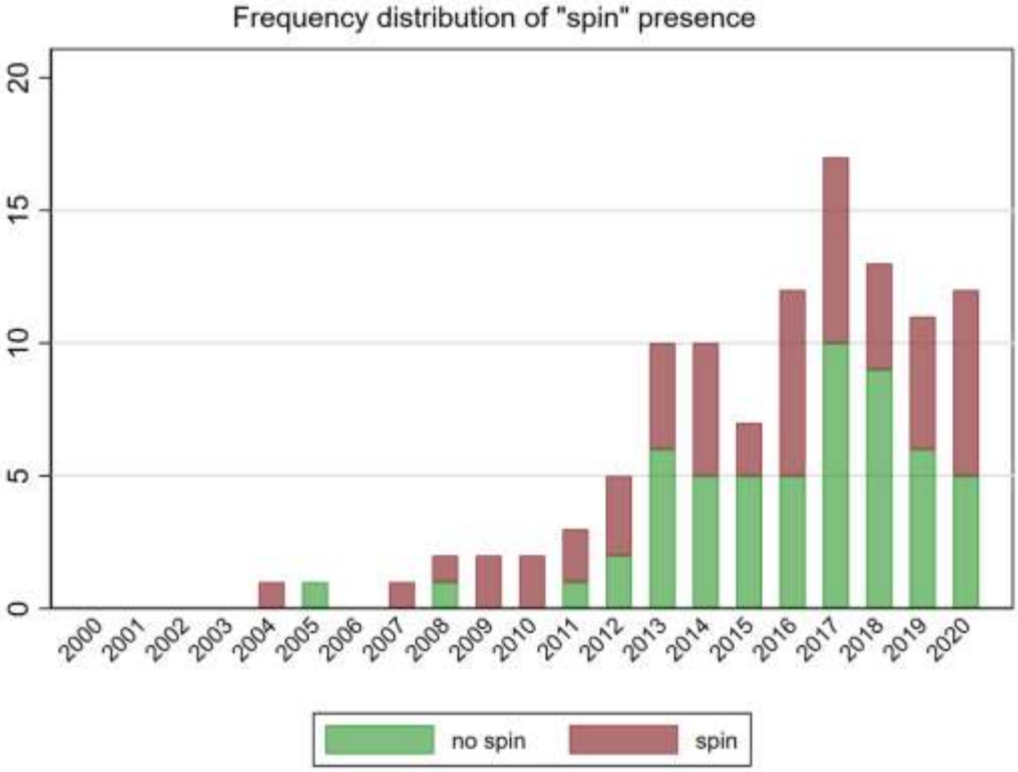
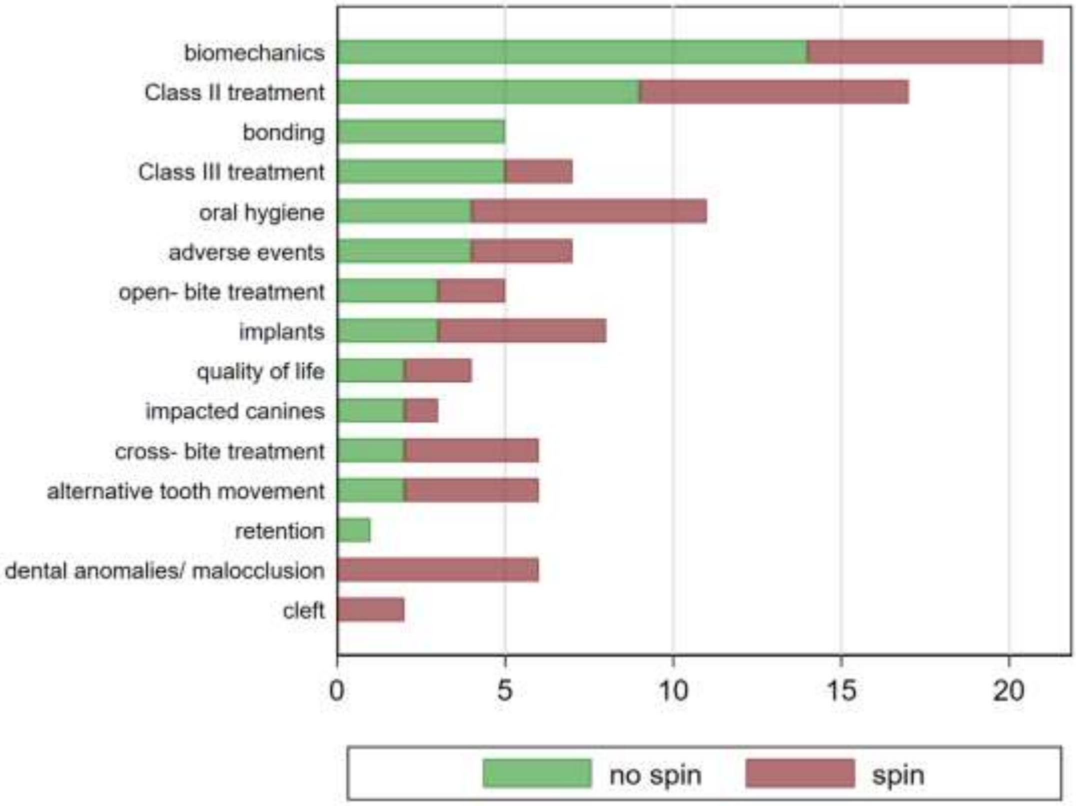

Electronic search for Systematic Reviews (SRs) in 5 leading Orthodontic Journals and the Cochrane Database (CDSR) from January 2000 to August 2020
322 records retrieved
Excluded (34)
- 16 Diagnostic SRs
- 16 SRs of in- vitro/ animal studies
- 2 network/ bayesian methods
288 records left for full- text screening against eligibility criteria
Excluded (179)
- SRs without quantitative synthesis
109 SRs with meta-analyses included

Figure 2



Frequency distribution of "spin" presence
0
5
10
15
20
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
no spin
spin

Figure 3


biomechanics
Class II treatment
bonding
Class III treatment
oral hygiene
adverse events
open- bite treatment
implants
quality of life
impacted canines
cross- bite treatment
alternative tooth movement
retention
dental anomalies/ malocclusion
cleft
0
5
10
15
20
no spin
spin