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Exploring online oral health misinformation: a content analysis

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Abstract: Considering the unfavorable implications of health falsehoods and the lack of dental research into information disorder, this study aimed to identify and characterize online oral health misinformation. A total of 410 websites published in English were retrieved using Google Advanced Search and screened by two independent investigators to compile falsehoods through thematic content analysis. Afterward, 318 pieces of misinformation were consensually divided into four groups concerning their informational interest (G1), financial, psychological, and social interests produced/disseminated by non-dental professionals (G2) or by dental professionals (G3), and political interests (G4). Social media (Facebook and Instagram) and fact-checking tool (Snopes) were also screened to determine the spread of falsehoods by identifying corresponding posts and warnings. As a result, misinformation was mainly associated with gum diseases (12.0%), root canal treatment (11.6%), toothache (10.4%), fluoride (10.4%), and dental caries (9.8%), with a special highlight on recommendations for the usage of natural products, toxicity concerns, and anti-fluoridation propaganda. Additionally, most misinformation was allocated in G3 (41.9%), which presented a statistically higher frequency of financial interests than G4. Finally, falsehoods were considerably identified on Facebook (62.9%) and Instagram (49.4%), especially G3 and G4. Nevertheless, Snopes has debunked only 5.9% of these content items. Therefore, misinformation was predominantly produced or disseminated by dental professionals mainly motivated by financial interests and usually linked to alternative/natural treatments. Although these items were shared on social media, fact-checking agencies seemed to have limited knowledge about their dissemination.

Keywords: Telemedicine; Information Seeking Behavior; Internet; Communication; Social Media.

Introduction

The increased production and consumption of false or misleading online health information are stimulated by self-opinions and autonomous behaviors of digital users who have originated from the era of hyperconnectivity.[1,2] The content overload observed in contemporary information ecosystems makes message processing difficult,[3] leading to the development of negative health beliefs that

hamper the decision-making process and the self-management of particular conditions, having adverse consequences for quality of life.[4,5]

In this context, the sense of innovation is a determining factor for the wide dissemination of falsehoods online.[6,7] At the microlevel, people are stimulated to share content by the judgment of their believability through the analysis of information sources, narratives, and context. Conversely, messages are distributed at the macrolevel without in-depth assessments in a cascade pattern.[1] Notably, 80% of users trust the authenticity of online information, which corroborates the more frequent sharing of misleading than trustworthy content on social media.[7-9]

Hence, the identification of oral health information disorder in digital environments is essential to fight frauds and hoaxes on the Internet.[10] As a result, user-centered educational oral health interventions may be implemented, helping resolve significant individual and community matters.[11] Also, this screening supports the development of artificial intelligence algorithms for the automated detection of health misinformation, which prevents the creation and dissemination of falsehoods.[12]

It has been previously demonstrated that Internet seekers are usually interested in oral health information on themes such as toothache, dental caries, molar incisor hypomineralization, and fluoride.[13-17] Considering the unfavorable implications of health falsehoods and the lack of dental research into information disorder, this study aimed to identify and characterize online oral health misinformation. We hypothesized that misinformation with non-informational interests and/or published by health professionals is more frequently spread on social media and detected by fact-checking agencies than misinformation with informational interests.

Methodology

Study design

This infodemiological qualitative study aimed to identify and characterize online oral health misinformation. Websites published in English were therefore retrieved using Google Advanced Search and screened by two independent investigators to compile false or misleading messages through thematic content analysis.[18,19] Based on a conceptual framework, content items were divided into four groups: misinformation with informational interests; misinformation with financial, social, and/or psychological interests produced or disseminated by non-dental professionals; misinformation with financial, social, and/or psychological interests produced or disseminated by dental professionals; and misinformation with political interests.[5,6,10,19-25] To determine the spread of content items, social media (Facebook and Instagram) and a fact-checking tool (Snopes) were respectively screened to identify corresponding posts and warnings.

Ethics

This study did not require institutional review board approval by the Human Research Ethics Committee of the Bauru School of Dentistry because federal regulations do not apply to research using publicly available data that do not involve human subjects.

Conceptual framework

We analyzed current concepts, terminologies, and taxonomies of information disorder to guide the investigations performed in this study. The definitions of terms were synthesized based on the most accepted theories, as follows: a) misinformation: false information determined based on a grounding of truth and applied only to informationally oriented content; b) fake news: intentionally misleading and biased representational information for the benefit of the sender of the message, which contains false information, with or without a blend of one or more components of omitted important information, a decontextualized content, misleading headlines or clickbait; c) disinformation: information that is false and deliberately created to harm a person, social group, organization or country; d) malinformation: the sharing of accurate information with the intention to cause harm; and e) conspiracy theory: attempts to explain the ultimate causes of significant social and political events and circumstances with

claims of secret plots by two or more powerful actors.[6,10,19-25] Moreover, distinct types of interests may underlie false or misleading online content.

Regarding the aforementioned concepts, content items were characterized according to three objective criteria:

a. The detection of false or misleading content (yes or no), including non-evidence-based information as proposed by Swire-Thompson and Lazer.[5] This process regarded the message context to identify possible misinterpretation or imprecise use of information;
b. The identification of interests (yes or no) behind the content, authors, and websites. The interests were classified as informational (warnings against deceitful content and beliefs), financial (profit from information disorder through advertising), political (attempts to influence public opinion in relation to political position), social (connection with online or offline groups), and/or psychological (seeking prestige or reinforcement), as stated by Wardle and Derakhshan.[6] From this perspective, misinformation can present multiple interests at the same time (e.g., social, financial, and psychological), except for those informational ones with a single interest.
c. The definition of the scientific background of content producer(s) or disseminator(s) (dentists/oral health companies or others), combined with the technical knowledge that enables specialists to identify false or misleading oral health information, concerning the professional responsibility of promoting those issues in digital environments.

Figure 1 depicts the decision tree used to divide content items into groups according to distinct characteristics of interest and authorship, as follows: G1 – misinformation with informational interests; G2 – misinformation with financial, social, and/or psychological interests produced or disseminated by non-dental professionals; G3 – misinformation with financial, social, and/or psychological interests produced or disseminated by dental professionals; and G4 – misinformation with political interests. This structure considered the objective contextual analysis that could be associated with the intentional production or dissemination of false or misleading information because the determination of intentionality is hinged upon subjective factors, making it difficult to standardize the analysis. According to Poe's law, the clues left by newsmakers are often inadequate to differentiate between honest and dishonest mistakes.[3,26]

Data collection

Between February 4 and February 23, 2021, websites published in English were retrieved using Google Advanced Search – the market leader in search engines in English-speaking countries.[27] The systematization of data collection is summarized in Figure 2. Initially, an exploratory analysis of the main dental fields was made through predetermined search strategies using Boolean operators. The queries were created by the intersection of a "specific field" AND ("fake news" OR disinformation). Previously, the Microsoft Edge browser language was set to English, with all cookies and history cleared to minimize the influence of personal preferences on data collection. The first 10 websites (front page) were accessed for each search strategy, replacing repetitions and sponsored advertisements. Interestingly, 95% of the users who search for health information on Google only follow links on the first page.[28] All the selected links were registered in Archive Today to ensure that websites remain unchanged and saved in a public repository for further analysis.[29,30]

Ten main dental fields (general dentistry, cariology, oral medicine, restorative dentistry, endodontics, prosthodontics, orthodontics, pediatric dentistry, periodontics, and surgery) were applied in the first stage. Only the queries concerning general dentistry and cariology did not retrieve websites. Thus, between March 1 and April 22, 2021, two independent investigators (ML and OSJ) manually analyzed the first 80 websites through thematic content analysis to identify misleading information. To do that, the investigators coded each sentence on the webpages as 0 (information) or 1 (false or misleading content).[18,19] Each false or misleading content item and its respective authors'

contextualization were tabulated in association with a particular dental field. These findings were then entered into a single table to eliminate possible repetitions.

Afterwards, in the second stage, seven themes known to be related to general dentistry and cariology (dental caries, flossing, fluoride, mouthwash, toothache, toothbrushing, and toothpaste) and three themes usually observed among fields without the identification of misleading content (oral cancer, root canal, and teeth whitening) were explored to retrieve more 100 websites. Additionally, 20 new themes that appeared in the first and second stages of the analysis led to the collection of more 200 websites (third stage). After that, three other new themes emerged from the third stage, requiring the retrieval of additional 30 websites (fourth stage), when thematic saturation occurred. The screening resulted in 410 websites with the identification of 369 non-repeated potentially false or misleading content items.

Identification and characterization of false or misleading oral health information

Between April 27 and July 5, 2021, other two independent investigators (ML and TC) manually

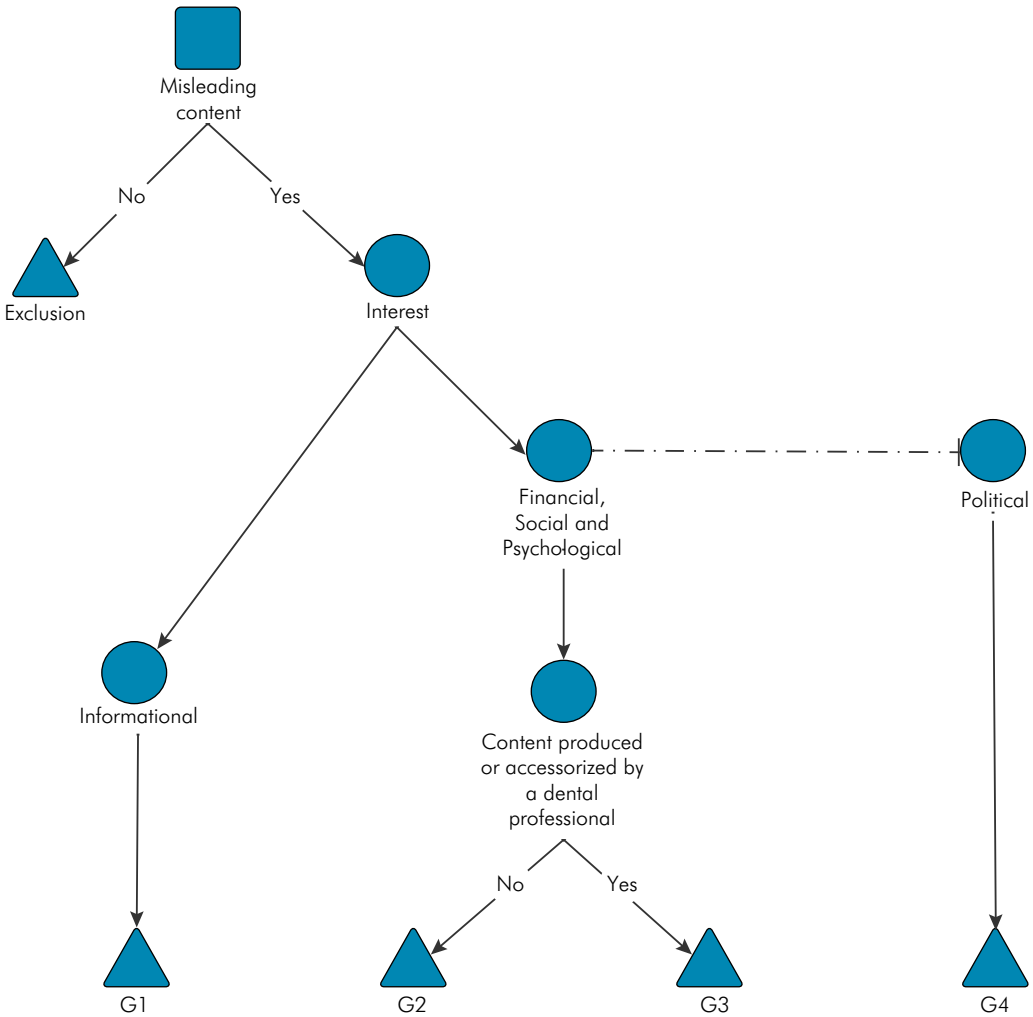

Figure 1. Decision tree for categorization of online oral health misinformation. G1 contains misinformation with informational interests, G2 contains misinformation with financial, social, and/or psychological interests produced or disseminated by non-dental professionals, G3 contains misinformation with financial, social, and/or psychological interests produced or disseminated by dental professionals, and G4 contains misinformation with political interests.

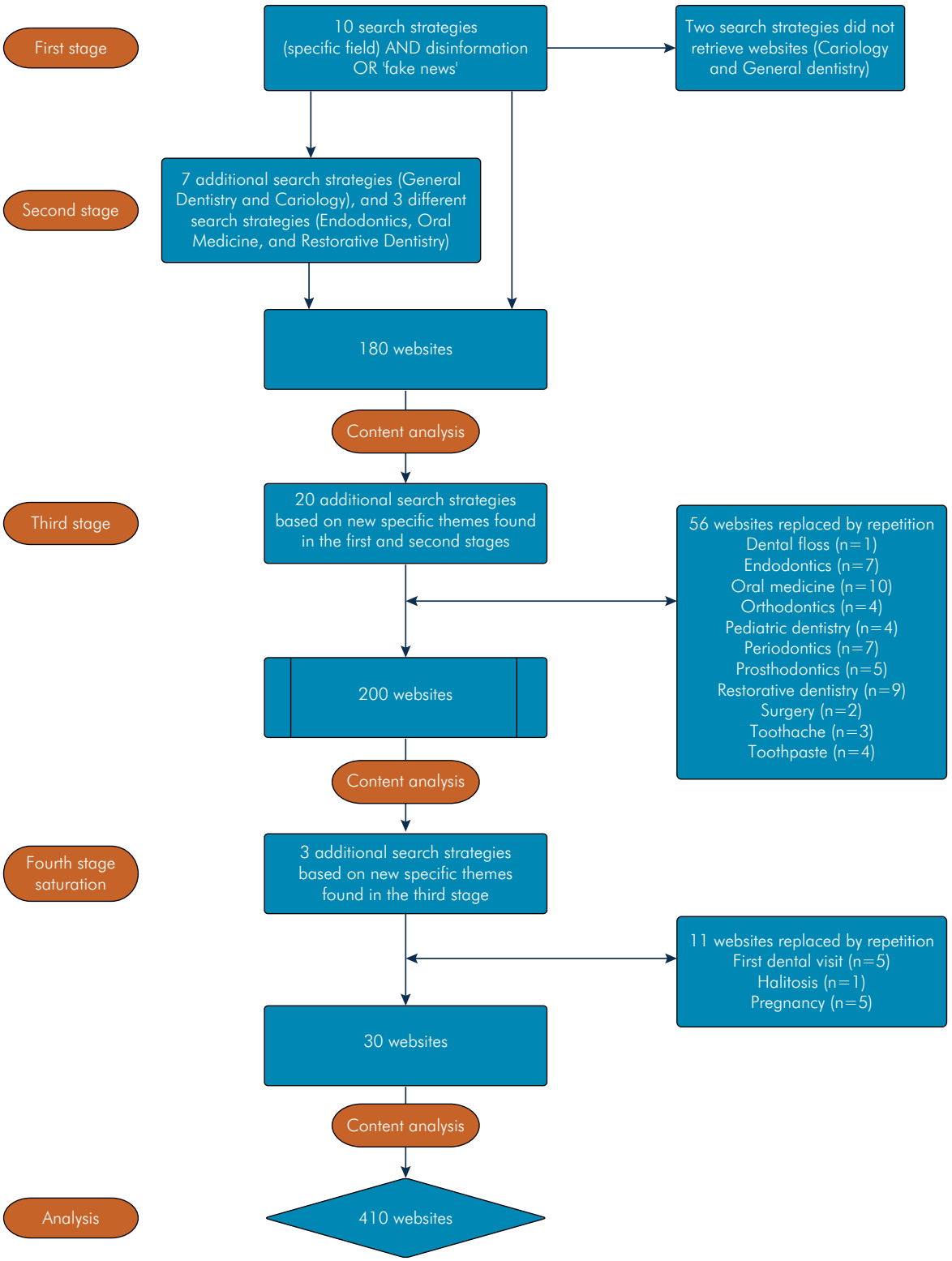

Figure 2. Flowchart depicting retrieval from websites.

analyzed potentially false or misleading content items, considering their context on websites. The items divergently qualified by the examiners were reassessed until a consensus could be reached. Fifty-one items were excluded from the analysis because they were related to supportive results of systematic reviews, clinical trials, or cohort studies published in international journals indexed in the Cochrane, Embase Search, Clinical Trials, Ovid, PubMed, Scopus, and/or Web of Science databases. Each of the 318 false or misleading content items was then allocated to a group, as mentioned earlier (Table 1).

The publication of misinformation on Instagram and Facebook was verified using the CrowdTangle,[31] considering the popularity of posting on social media worldwide.[32] Interestingly, this platform permits data analysis of public accounts and pages from these social networks. A single evaluator (ML) accessed available publications until he could screen at least one falsehood, including photos, videos, links, and status. Also, the Snopes fact-checking tool was accessed to determine whether oral health misinformation had been debunked previously.[33] The main words in each false or misleading content item were applied to search posts and warnings using Boolean operators on both platforms. For example, the item described as *"fluoride may cause cancer"* was synthesized as fluoride AND cancer.

For further details, please see the public data repository.[30]

Data analysis

Statistical analysis was performed using the Statistical Package for Social Sciences (v. 21.0; SPSS; Chicago, USA). Thematic nodes and subnodes that emerged from the content analysis were represented by a conceptual map. Also, data were evaluated by descriptive analysis and Cramer's V test to compare distinct categories of misinformation according to the frequencies of types of interest (informational, financial, social, psychological, and political), detection on social media (Facebook and Instagram), and fact-checking agency (Snopes). For all analyses, p-values <.05 were considered significant.

Results

Oral health misinformation is summarized in Table 1. Most items were allocated in G3 (41.9%), followed by G2 (24.8%), G1 (24.2%), and G4 (9.1%). Social and psychological interests were mainly detected among misinformation items, with more than 54.2% of them related to five themes: gum diseases (12.0%), root canal treatment (11.6%), toothache (10.4%), fluoride (10.4%), and dental caries (9.8%). A substantial percentage of items were identified on Facebook (62.9%) and Instagram (49.4%). In contrast, Snopes debunked only 5.9% of misinformation. Notably, content with political interests focused on fluoride-related information, supporting anti-fluoridation propaganda.[30]

Table 2 depicts the distribution of types of interests, presence on social media, and fact-checking detection according to the categories of misinformation. The financial interest was statistically higher in G2 and G3 as compared to G4, with a higher frequency in G3. Furthermore, no distribution statistics were computed for social and psychological interests, given that they were constant (100%) in G2, G3, and G4. Likewise, the distribution of political interests could not be compared because they were present only in G4. Also, misinformation in G3 and G4 was detected more significantly on Instagram than in G1. Similar percentages of all categories of false or misleading content were checked and publicized by Snopes.

Figure 3 presents a conceptual map of oral health misinformation obtained from the content analysis. It demonstrates the relationship of nine nodes (fields), 18 first-level subnodes (themes), and 50 second-level subnodes (context). The most commonly identified contexts were recommendations of home remedies and natural products (32.1%), toxicity concerns (16.3%), anti-fluoridation propaganda (9.1%), and alternative medicine (6.6%).

Discussion

To our knowledge, this is the first study to identify and characterize online oral health misinformation.

Table 1. Summary of web content classified according to the field, themes, interest, category of misleading information, publication on social media, and detection by Snopes fact-checking tool.

Fields and themes	n	Interest					Groups				Social media			Fact-checking
		Financial	Social	Political	Psychological	Informational	G1	G2	G3	G4	Facebook	Instagram	None	Snopes
Cariology														
Dental caries	31	5 (16.1%)	27 (87.1%)	0	27 (87.1%)	4 (12.9%)	4 (12.9%)	18 (58.1%)	9 (29.0%)	0	19 (61.3%)	17 (54.8%)	12 (38.7%)	3 (9.7%)
Fluoride	33	3 (9.1%)	29 (87.8%)	29 (87.8%)	29 (87.8%)	4 (12.2%)	4 (12.2%)	0	0	29 (87.8%)	26 (78.8%)	21 (63.6%)	7 (21.2%)	2 (6.1%)
Endodontics														
Root canal treatment	37	24 (64.8%)	24 (64.8%)	0	24 (64.8%)	13 (35.2%)	13 (35.2%)	0	24 (64.8%)	0	24 (64.8%)	18 (48.6%)	13 (35.2%)	2 (5.4%)
General dentistry														
Dental floss	14	4 (28.6%)	11 (78.6%)	0	11 (78.6%)	3 (21.4%)	3 (21.4%)	4 (28.6%)	7 (50.0%)	0	8 (57.2%)	5 (35.7%)	6 (42.8%)	1 (7.1%)
Mouthwash	22	13 (59.1%)	17 (77.3%)	0	17 (77.3%)	5 (22.7%)	5 (22.7%)	4 (18.2%)	13 (59.1%)	0	15 (68.2%)	16 (72.7%)	4 (18.2%)	5 (22.7%)
Toothache	33	10 (30.3%)	32 (96.9%)	0	32 (96.9%)	1 (3.1%)	1 (3.1%)	17 (51.5%)	15 (45.4%)	0	19 (57.6%)	17 (51.5%)	13 (39.4%)	1 (3.1%)
Toothbrushing	13	5 (38.4%)	7 (53.8%)	0	7 (53.8%)	6 (46.2%)	6 (46.2%)	5 (38.4%)	2 (15.4%)	0	7 (53.8%)	6 (46.2%)	6 (46.2%)	1 (7.7%)
Toothpaste	23	14 (60.8%)	18 (78.2%)	0	18 (78.2%)	5 (21.8%)	5 (21.8%)	10 (43.4%)	8 (34.8%)	0	15 (65.2%)	14 (60.8%)	8 (34.8%)	0
Oral medicine														
Halitosis	1	1 (100%)	1 (100%)	0	1 (100%)	0	0	0	1 (100%)	0	0	0	1 (100%)	0
Oral cancer	16	0	8 (50.0%)	0	8 (50.0%)	8 (50.0%)	8 (50.0%)	8 (50.0%)	0	0	8 (50.0%)	5 (31.2%)	8 (50.0%)	0
Orthodontics														
Dental braces	12	0	0	0	0	12 (100%)	12 (100%)	0	0	0	9 (75.0%)	0	3 (25.0%)	0
Pediatric dentistry														
Amber necklace	6	6 (100%)	6 (100%)	0	6 (100%)	0	0	6 (100%)	0	0	6 (100%)	6 (100%)	0	0
Deciduous teeth	10	3 (30.0%)	6 (60.0%)	0	6 (60.0%)	4 (40.0%)	4 (40.0%)	1 (10.0%)	5 (50.0%)	0	1 (10.0%)	1 (10.0%)	9 (90.0%)	1 (10.0%)
First dental visit	1	0	0	0	0	1 (100%)	1 (100%)	0	0	0	0	0	1 (100%)	0
Oral health pregnancy	2	0	1 (50.0%)	0	1 (50.0%)	1 (50.0%)	1 (50.0%)	0	1 (50.0%)	0	1 (50.0%)	1 (50.0%)	1 (50.0%)	0
Periodontics														
Gum diseases	38	15 (39.5%)	38 (100%)	0	38 (100%)	0	0	1 (2.6%)	37 (97.4%)	0	22 (57.9%)	18 (47.3%)	16 (42.1%)	3 (7.9%)
Restorative dentistry														
Teeth whitening	10	0	0	0	0	10 (100%)	10 (100%)	0	0	0	5 (50.0%)	5 (50.0%)	5 (50.0%)	0
Surgery														
Wisdom teeth	16	11 (68.8%)	16 (100%)	0	16 (100%)	0	0	5 (31.2%)	11 (68.8%)	0	15 (93.8%)	7 (43.7%)	1 (6.2%)	0
Total	318	114 (35.5%)	241 (75.9%)	29 (9.1%)	241 (75.9%)	77 (24.1%)	77 (24.5%)	79 (24.5%)	133 (41.9%)	29 (9.1%)	200 (62.9%)	157 (49.4%)	114 (35.8%)	19 (5.9%)

Table 2. Distribution of interest, social media, and fact-checking according to the categories of misinformation.

Misinformation	Social media		Fact-checking	Interest
	Facebook n (%)	Instagram n (%)	Snopes n (%)	Financial n (%)
G1 (n = 77)	41 (53.2%)a	26 (33.7%)a	6 (7.8%)a	*
G2 (n = 79)	49 (62.0%)a	358 (48.1%)a,b	2 (2.5%)a	33 (41.8%)a
G3 (n = 133)	88 (66.2%)a	75 (56.4%)b	9 (6.8%)a	78 (58.6%)a
G4 (n = 29)	22 (75.9%)a	18 (62.1%)b	2 (6.9%)a	3 (10.3%)b
ϕ	0.135	0.195	0.085	0.314
p-value	0.122	0.007	0.510	< 0.001

Different superscript lowercase letters indicate significant statistical differences between categories;*Exclusion criteria for the group.

These findings indicate items that were predominantly produced or disseminated by dental professionals presented a higher frequency of financial interests than in the other groups. Most items were linked to gum diseases, root canal treatment, toothache, fluoride, and dental caries, with a special highlight on recommendations of home remedies and natural products, toxicity concerns, anti-fluoridation propaganda, and alternative medicine. Misinformation items with political interests were related to fluoride. Content items of groups G3 and G4 were significantly more frequently detected on Instagram than in G1. Even with the diffusion of content on social media, items were rarely debunked by Snopes.

These outcomes confirm that messages with interests and by dental professionals were more usually found on social media than was informationally oriented misinformation. In this sense, public health measures and policies, such as water fluoridation, were systematically depreciated due to political interests,[34] *e.g.*, *"water fluoridation is a communist plot to control minds*," and "*water fluoridation is designed to boost the sugar lobby*." These outcomes are in agreement with the behavior of Twitter users who were mostly interested in content that emphasized the negative health aspects of fluoride measures.[15] This can be explained by the concurrence of multiple factors, such as the sense of innovation of falsehoods, information overload, and weak-tie relationships on social networks, which are inflated by predisposing personal characteristics of users in the form of preexisting beliefs, ideological motivations, and political polarization.[1,9,35]

The higher frequency of financial interests detected in G3 demonstrates a low concern of several dental professionals and companies with the production of precise and correct posts. In this sense, a high percentage of those misinformation items discouraged the use of traditional oral care products, *e.g.*, *"glycerin present in toothpastes can make teeth yellow*," *"triclosan present in toothpastes affects heart function*," and "*use of dental floss may cause Alzheimer's disease*," or offered miraculous homemade self-management of conditions, *e.g.*, *"oil pulling reduces bacterial load in the mouth and helps with dental caries prevention*," *"applying pepper paste can provide relief in case of a toothache*," and "*neem has been shown to help to prevent oral cancers*." These arguments might aim to supply a demand for poorly accessible dental care services, exploring personal preferences for natural products.

Nevertheless, it is relevant to consider possibly fraudulent content authorship because this aspect is difficult to verify online; however, if this hypothesis is confirmed, fabricated messages must be regarded as disinformation, which in theory is more rapidly diffused on social media than informationally oriented messages.[36] Thus, our model proved to be effective for characterizing false or misleading content because it demonstrated a proportional increase of the availability of items on social media in parallel to the detection of non-informational interests and authorship credited to dental professionals (53.2% to 75.9% on Facebook, and 33.7% to 62.1% on Instagram). Dental professionals and companies are expected to be more able to avoid

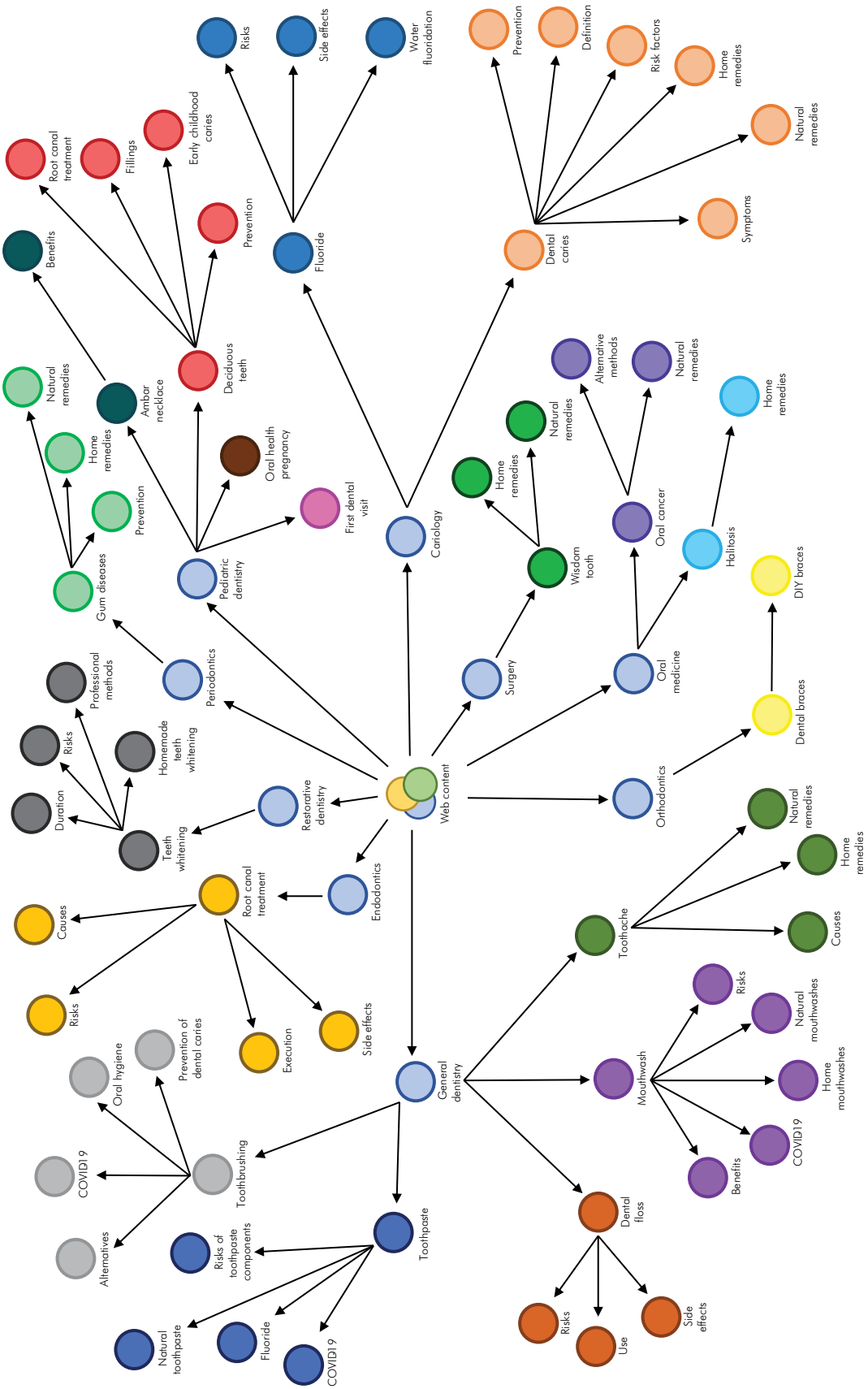

Figure 3. Conceptual map showing the relationship of fields, themes, and context of online oral health misinformation identified on websites.

and recognize incorrectness or falsehood in technical publications and posts than would other people, *i.e.*, they must be alerted about their considerable responsibility to promote oral health information as social authorities.

Considering that the attention of fact-checking agencies is aroused by the main interests of digital users,[1] the detection of low frequencies of debunked content on Snopes may denote the absence of criticism and awareness of oral health information seekers, either by limitations related to their eHealth and media literacy or by ignoring the possible negative effects of false or misleading content. Additionally, authorities still lack awareness of the prominence of information disorder in digital environments, culminating in the deficiency of policies and online surveillance systems to promote the identification of false or misleading information.[36,37]

These findings should be interpreted with caution. First, it is not possible to affirm that this methodological approach was able to identify all existent and currently available online oral health misinformation because these outcomes were dependent on choices of systematization; however, a large volume of web content was retrieved until thematic saturation occurred. Second, the results might be influenced by Google algorithms that retrieve links and consider information seekers' personal preferences. This aspect was minimized by clearing all browsing history and cookies before proceeding with the searches. Third, as we focused our analyses on identifying the maximum number of materials linked to information disorder, digital users are not necessarily consuming the evaluated content. Fourth, although English is the most spoken language worldwide, the detection of false information was probably influenced by cultural aspects not observed universally.

This study contributes to the development of further investigation and technologies in a multifaceted way, in reference to: a) the definition of the scope of online oral health misinformation over time, b) the characterization of false or misleading content items to define correct inputs for artificial intelligence-based detection systems, c) the construction of models and methods to assess the dissemination of false or misleading information on social media, and d) the evidence on how false or misleading content might influence the decision-making process in clinical situations to elucidate upcoming schemes. Also, the results have the potential to support fact-checking agencies and dental associations to issue warnings about deceitful messages to their audience immediately. In this context, dental professional teams need to be aware of false content to improve the quality of their relationship with patients through appropriate communication. They also need to educate patients about the harmful effects of health misinformation, such as the damaging consequences of natural treatments for oral cancer and dental caries. Moreover, these outcomes foster public debate on the prevention of the creation and dissemination of incorrect information and falsehoods. Thus, lawmakers may create guidelines and laws to control the spread of oral health misinformation.

Conclusions

Online oral health misinformation retrieved by Google Search was predominantly produced or disseminated by dental professionals and was mainly motivated by financial interests. Frequently, misinformation was linked to the diffusion of alternative and natural treatments. The fact that publications related to dental professionals and non-informational interests were more commonly found on social media is noteworthy; however, fact-checking agencies seemed to have limited knowledge about their existence and dissemination among digital users. Therefore, our hypothesis was partially confirmed. We hope these outcomes can significantly contribute towards the development of innovative tools and policies to combat oral health misinformation.

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