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Untangling the truth: User engagement with misinformation in toothache-related Facebook posts

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Objective: Social media is a platform for sharing views on aspects of life, including oral health. This study aimed to characterize Facebook posts related to toothache information. ***Methods***: Two independent investigators retrieved 500 English-language posts with the highest level of interaction using CrowdTangle™ and analyzed their facticity, motivation, author's profile, content, sentiment, and type of post. Data were analysed descriptively and using Pearson's Chi-square and Mann-Whitney U tests and multiple logistic regression models. ***Results***: Most posts were produced by regular users and were not financially motivated, although commercial posts had significantly higher total interaction among users. While link- or video-containing posts (OR = 1.66) and posts with positive sentiments (OR = 1.53) were associated with users' total interaction, older (OR = 1.81) and link- or video-containing posts (OR = 2.04) were associated with overperforming scores. Misinformation was positively associated with financial motivation (OR = 2.03) and positive sentiments (OR = 3.79). ***Conclusion***: This study highlights the importance of addressing the spread of misinformation related to oral health on social media and taking steps to ensure that accurate and reliable information is readily available. Toothache-related misinformation was associated with positive sentiments and financial motivation. Links, videos, and positive sentiments awakened greater user engagements with toothache-related posts.

Keywords*: health behavior, toothache, social media, misinformation, ehealth*

Introduction

The democratization of health information through digital tools has increased the availability of oral health information on the internet, promoting autonomy and information exchange among users (Rizzato *et al*., 2021). However, the vast amount of information available has made it difficult to filter quality content, leading to consumption of false information and unhealthy beliefs (Giglietto *et al*., 2019). Despite a lack of evidence-based support, people tend to accept and share misleading information, contributing to the spread of harmful information (Mainous, 2019).

Social media platforms contain misleading health information on important topics such as vaccines, drugs or smoking, noncommunicable diseases, pandemics, eating disorders, and medical treatments (Suarez-Lledo and Alvarez-Galvez, 2021). False information can modify behaviours, damage patient–professional relationships, and influence decision-making (Larson, 2018).

Toothache is orofacial pain arising from pathological conditions affecting dental structures and their adjacent tissues, such as dental caries, periodontal disease, dental trauma, occlusal dysfunction, and abscesses (Cohen *et al*., 2009). It is more prevalent among economically disadvantaged people and impairs quality of life. Therefore, people experiencing toothache often turn to the internet to find ways to manage pain and seek treatment options, such as home remedies and medications, and assistance in finding a dentist (Lotto *et al*., 2020). However, low quality toothache information available online can lead people to attempt to solve dental problems using lay knowledge, which can cause further aggravation of issues (Lotto *et al*., 2020).

Facebook remains a prominent social media platform and serves as a critical channel for health-related information (Sharma *et al*., 2017). Although Facebook is often utilized to access and disseminate health-related information, a notable absence of validation this content can allow the dissemination of misinformation. Furthermore, users commonly interact with Facebook content that substantiates their pre-existing beliefs, thereby facilitating the resolution of conditions using empirical methodologies (Nyhan *et al*., 2023). This infodemiology study aimed to identify and characterize toothache-related posts found on Facebook in English and to determine the predictive factors of higher user engagement with posts. These findings could inform public health policies and help combat the spread of misinformation on social media platforms.

Method

This study examined 500 posts related to toothaches published in English on Facebook between August 2016 and August 2021. The posts with the most total user interactions were collected using CrowdTangle™ with their respective dates of publication, total numbers of interactions, and overperforming scores. Two independent investigators conducted a qualitative analysis of the posts, categorizing them according to their facticity, motivation, author's profile, type of content, sentiment, and type of post. The research was exempted from institutional review board approval by the Council of Ethics in Human Research of the Bauru School of Dentistry as per federal regulations, which do not apply

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to research that uses publicly available data and does not involve human subjects. The raw anonymized data have been made available in the Figshare repository.

Data were collected using a search strategy with keywords related to toothaches and specific classification criteria. The strategy "toothache" + "tooth pain" + "teeth hurt" + "sensitive tooth" + "sore teeth" + "sore tooth" + "tooth hurts" + "tooth sensitivity" + "throbbing tooth" + "dental pain" was determined through exploratory analysis of terms and hashtags to ensure maximal recovery of toothache data from Facebook.

Data were collected using CrowdTangle™, a web scraping tool owned by Meta Platforms, Inc., that allows investigation of social media metrics, including posts, data, profile information, and performance scores using specific keywords. The use of CrowdTangle™ is limited to qualified organizations, such as university researchers. Our group was granted access to the platform for the purpose of studying false information in dentistry.

On February 12, 2022, a dataset of 10,000 posts in English published between August 2016 and August 2021 was downloaded as a .csv file. To ensure the inclusion of the most accessed posts, posts were ranked by total user interaction. The term "total interaction" refers to the sum of all reactions, shares, and comments received by a Facebook post. In addition, the "overperforming score" measures the diffusion performance of a post relative to the interaction of the last 100 posts on the same account at the same time. The overperforming score algorithm eliminates the top and bottom 25% of posts and determines the average number of interactions for the remaining middle 50% of posts during different time intervals (e.g., 15 minutes old, 60 minutes old, 5 hours old, etc.). Subsequently, when the account uploads a new post, the platform compares its metrics with the calculated average and applies the corresponding weights from each dashboard to the obtained difference.

Manual qualitative assessment of the raw dataset by one researcher selected a manageable number of posts related to toothache. To ensure data quality, 878 retrieved posts were analyzed according to the following exclusion criteria: (i) posts unrelated to toothaches (n = 8), (ii) posts produced by authors who were non-native English speakers (n = 28), (iii) posts with inaccessible links (n = 7), and (iv) duplicate posts (n = 335) (Figure 1).

All 500 remaining posts were included for analysis. Subsequently, posts were printed and anonymized by redacting names, profiles, and people's eyes in images. To ensure standardization and prevent inconsistencies, the posts were numbered and saved in sequence in Google Slides (Google, Mountain View, CA, USA). This file was later converted to a .pdf file. This process allowed for the ethical analysis of messages by different investigators at different times.

Two investigators were trained for qualitative analysis of posts using protocols and discussing representative features of previous Facebook posts (Franz *et al*., 2019)

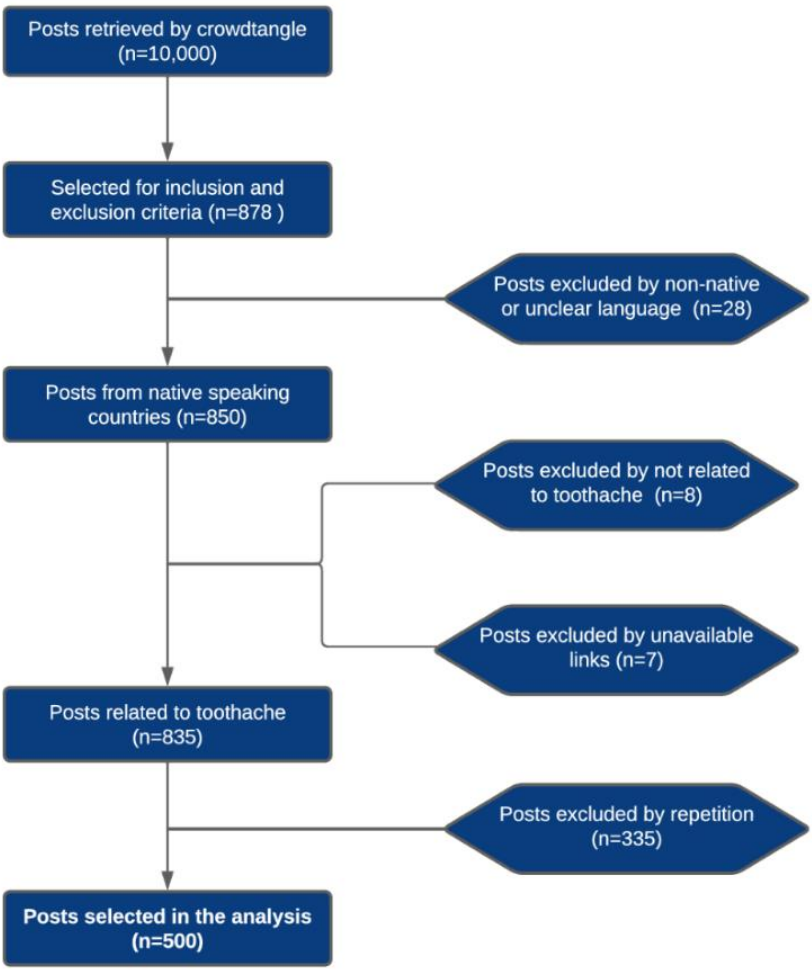

Figure 1. *Flowchart of posts' selection.*

that contained toothache-related content. Additionally, investigators were calibrated by the independent assessment of 10% of the total posts (n = 50), considering intraclass correlation coefficients (ICCs) greater than 0.8 to indicate adequate inter-examiner agreement. The agreement between investigators was high, ranging from 0.83 to 0.91.

Investigators classified posts using the following criteria: facticity (information, misinformation, or satire), author's profile (regular user, company, dental office, health professional, or news agency), type of content (noncommercial or commercial), motivation (financial or non-financial), sentiment (positive, neutral, or negative), and type of post (photo, status, link, or video). In cases of disagreement, the investigators reviewed the posts again to reach a consensus and ensure the quality of the analysis.

For a post to qualify as containing misinformation, it had to present assertions that were unequivocally incorrect or deceptive and were not supported by scientific evidence, thereby posing a risk of harm to Facebook users. This included, for instance, endorsing home remedies or alternative/spiritual methods without scientific validation as ways to manage or alleviate dental pain.

Analysis author's profiles considered a description of profiles and pages accessed on Facebook to classify them as a regular user (including digital influencers or bloggers), company (commercial company, store, profile containing posts from news media or news agencies), or dental office (pages of dentists, health professionals, clinics, or hospitals).

The motivation for posting false or misleading digital content can be varied, benefiting users' social (connection with a group), financial (seeking profit using misleading information), political (attempting to influence the opinion of others due to political positions), or psychological (aiming to gain prestige or reinforce an idea) interests (Wardle and Derakhshan, 2017). Deciphering the intentionality of digital content is challenging due to inadequate traces left by content authors to identify whether they intended to produce misleading information or not (Giglietto *et al*., 2019). In this sense, misinformation was used as an umbrella term that encompassed false or misleading content with or without the intention to harm; this included two types of information disorder: misinformation *per se* and disinformation (Wardle and Derakhshan, 2017). The sentiment analysis categorized the content based on observable signals. The detection of smiles, words related to relief and healing, motivational ideas, or happy emojis were related to positive sentiments. In contrast, the identification of sad people; text loaded with negative connotations; words related to disease, pain, or suffering; or negative emojis were related to negative sentiments. Content that was expressed with rationality, such as scientific results or journalistic news, was classified as having a neutral sentiment.

Analysis was conducted using SPSS (v. 28.0; Chicago, IL, USA). First, the variables were dichotomized based on the following criteria: time of publication (≤ 827 days or > 827 days), motivation (financial or non-financial), author's profile (regular user or business/health), type of content (noncommercial or commercial), sentiment (negative/neutral or positive), type of post (photo/status or link/video), total interactions (≤ 3328 or > 3328), and overperforming score (≤ 4.0 or > 4.0). Continuous variables were dichotomized around their median values. Dental offices, news agencies, and businesses were categorized in the same group due to a common financial history. Importantly, satire is often associated with false or misleading information, sensationalist news, or the use of irony and exaggeration; this can confuse the reader, even if such posts are not intended to be harmful. For this reason, satire was considered to be negative, like misinformation and in contrast to informational content (Kapantai *et al*., 2021). The choice to make positive sentiment an independent category was based on prior studies indicating a link between positive emotions and higher social media user engagement rates (Klassen *et al*., 2018). Data normality and homogeneity were checked using Kolmogorov–Smirnov and Levene's tests. As the data did not follow a normal distribution, Mann–Whitney U tests compared the total interactions and overperforming scores of the dichotomized variables. Pearson's Chi-square tests were used to analyze differences in the distributions of dichotomized variables according to the facticity of the posts (information, misinformation, or satire). Multiple logistic regression models assessed the associations of misinformation, total interaction, and overperforming score with the aforementioned variables. The multiple regression models included only factors with significant Wald statistics in the bivariate analyses. A significance level of $P < 0.05$ was employed for all analyses.

Results

Posts were categorized as information (55.6%, e.g., "I have a toothache"), misinformation (32.1%, e.g., "eat more ginger to cure toothache"), and satire (12.3%, e.g., "he is so sweet he'll make your teeth hurt"). Posts were predominantly noncommercial (90.8%, e.g., "I'd rather give birth again than have a toothache"), produced mostly by regular users (57.6%), expressing positive sentiments (60.8%, e.g., "you'll get long-lasting relief from tooth sensitivity and enjoy life again"), and posted with a photo/status (70.8%). Most (51%) motivations were classified as non-financial. Overperforming scores were higher in older posts (> 827 days). There were more total interactions for posts with commercial content, positive sentiments, and a link/video (Table 1).

Table 2 summarizes the distribution of dichotomized variables for each facticity category. Posts related to information and satire had greater financial motivation. Posts related to information expressed a predominance of negative sentiments, while those referring to misinformation or satire expressed a predominance of positive sentiments.

Multiple logistic regression models showed positive associations of misinformation with positive sentiments (OR = 3.79; 95%CI = 2.545, 5.637) and financial motivation (OR = 2.03; 95%CI = 1.392, 2.956). Total user interaction was associated with link/video (OR = 1.66; 95%CI = 1.122, 2.463) and positive sentiments (OR = 1.53; 95%CI = 1.061, 2.204). Overperforming score was associated with link/video (OR = 2.04; 95%CI = 1.359, 3.050) and older posts (OR = 1.81; 95%CI = 1.258, 2.603) (Table 3).

Table 1. Total interaction and overperforming scores by time of publication, motivation, author's profile, content, sentiment and type of post.

	n (%)	*Total interaction*		*Overperforming score*	
		Median (IQR)	*P (MWU test)*	*Median (IQR)*	*P (MWU test)*
Time of publication					
≤ 827 days	249 (49.8%)	3142 (7851)	0.100	3.06 (7.36)	0.003*
> 827 days	251 (50.2%)	3458 (5145)		6.11 (19.03)	
Motivation					
Non-financial	255 (51.0%)	3462 (5223)	0.053	4.73 (15.27)	0.191
Financial	245 (49.0%)	3070 (4156)		3.44 (9.9)	
Author's profile					
Regular user	288 (57.6%)	3393 (4482)	0.648	3.97 (11.29)	0.914
Business/health	212 (42.4%)	3162 (4881)		4.21 (12.50)	
Content					
Noncommercial	454 (90.8%)	3308 (4224)	0.037*	4.14 (11.73)	0.608
Commercial	46 (9.2%)	4606 (8463)		3.41 (12.77)	
Sentiment					
Negative/neutral	196 (39.2%)	3090 (3617)	0.033*	4.71 (3617)	0.365
Positive	304 (60.8%)	3549 (5134)		3.82 (11.14)	
Type of post					
Photo/status	354 (70.8%)	3090 (3860)	0.003*	3.32 (8.55)	0.001*
Link/video	146 (29.2%)	3973 (5852)		6.94 (14.9)	

*P < 0.05

Table 2. Information, misinformation, and satire by time of publication, motivation, author's profile, content, sentiment and type of post.

	Facticity			*P (Chi sq.)*
	Information	*Misinformation*	*Satire*	
	n = 273	*n = 163*	*n = 64*	
Time of publication				
≤ 827 days	131 (48.0%)[a]	83 (50.9%)[a]	35 (54.7%)[a]	0.591
> 827 days	142 (52.0%)[a]	80 (49.1%)[a]	29 (45.3%)[a]	
Motivation				
Non-financial	161 (59.0%)[a]	52 (31.9%)[b]	42 (65.6%)[a]	< 0.001*
Financial	112 (41.0%)[a]	111 (68.1%)[b]	22 (34.4%)[a]	
Author's profile				
Regular user	152 (55.7%)[a]	100 (61.3%)[a]	36 (56.2%)[a]	0.497
Business/health	121 (44.3%)[a]	63 (38.7%)[a]	28 (43.8%)[a]	
Content				
Noncommercial	248 (90.8%)[a]	145 (89.0%)[a]	61 (95.3%)[a]	0.329
Commercial	25 (9.2%)[a]	18 (11.0%)[a]	3 (4.7%)[a]	
Sentiment				
Negative/neutral	144 (52.7%)[a]	48 (29.4%)[b]	4 (6.2%)[c]	< 0.001*
Positive	129 (47.3%)[a]	115 (70.6%)[b]	60 (93.8%)[c]	
Type of post				
Photo/status	186 (68.1%)[a]	125 (76.7%)[a]	43 (67.2%)[a]	0.130
Link/video	87 (31.9%)[a]	38 (23.3%)[a]	21 (32.8%)[a]	
Total interaction				
≤ 3328	136 (49.8%)[a]	87 (53.4%)[a]	27 (42.2%)[a]	0.315
> 3328	137 (50.2%)[a]	76 (46.6%)[a]	37 (57.8%)[a]	
Overperforming score				
≤ 4.0	134 (49.1%)[a, b]	90 (55.2%)[b]	26 (40.6%)[a]	0.128
> 4.0	139 (50.9%)[a, b]	73 (44.8%)[b]	38 (59.4%)[a]	

Superscript letters indicate significant differences between groups at P < 0.05.

Table 3. Multiple logistic regression models for predictors of facticity, total interaction, and overperforming score.

	Odds Ratio (95% CI)
Facticity (misinformation/satire)	
Sentiment (positive)	3.788 (2.545, 5.637)
Motivation (financial)	2.029 (1.392, 2.956)
Type of post (link/video)	0.710 (0.468, 1.078)
Total interaction (> 3328)	
Type of post (link/video)	1.662 (1.122, 2.463)
Sentiment (positive)	1.529 (1.061, 2.204)
Motivation (financial)	0.740 (0.518, 1.057)
Overperforming score (> 4.0)	
Type of post (link/video)	2.036 (1.359, 3.050)
Time of publication (> 827 days)	1.810 (1.258, 2.603)
Motivation (financial)	0.697 (0.486, 1.001)

Discussion

This study analyzed toothache-related posts on Facebook to examine misinformation and interaction metrics. The posts were classified into three categories: information (n = 273), misinformation (n = 163), and satire (n = 64). Most posts were generated by regular users and were not financially motivated. Interestingly, false and satirical content tended to involve positive sentiments, whereas informational posts mostly expressed negative sentiments. Positive sentiments and financial motivation were predicted toothache misinformation, while posts containing a link/video and expressing positive sentiments predicted higher total user interaction. Longer time since publication and link/video predicted higher overperforming scores.

Whilst the content related to toothaches was predominantly produced by regular users and was non-commercial, it was influenced by alternative treatments and posts related to disease prevention. Users tended to interact more with this type of content due to information bias, which was driven by congruent arguments, and they might have accepted the content through confirmation bias (Kim *et al*., 2019). This highlights that people are susceptible to believing and sharing misleading information. This phenomenon in Internet users is influenced by the "strength of weak ties," which is characterized by weak and sporadic social ties that promote the rapid diffusion of innovative content due to the low uniformity of ideas (Granovetter, 1973). However, these individuals also feel the need for social ties and prefer similar thoughts and ideas shared by a certain group of people. The growth of communication tools has facilitated access to information and has involved high participation in the processes of content production and propagation, including on social media. Consequently, it is crucial for scientific evidence to challenge the public with reliable facts and confront pseudoscience on sources of mass communication (Mainous, 2018).

The relationship between positive sentiments and misinformation may be attributed to misleading content promoting home remedies and symptom relief, while informative content focuses on disease information. Here, posts containing misinformation frequently offered treatments and solutions for toothache, suggesting that congruent misinformation elicits positive emotions, whereas incongruent misinformation results in negative feelings. This finding supports the idea that congruent rumors are more likely to generate positive feelings about a particular topic than incongruent rumors (Mookherjee, 2023).

Posts with links and videos gaining higher engagement may be due to the moderate and high level of liveness observed in such content, which tends to invoke greater engagement than posts with low liveness, such as status updates or images/albums (Luarn *et al*., 2015). However, links can have a negative effect on the number of comments a post receives (Schultz, 2017). In contrast, videos can be linked to home treatment methods or natural products, which can attract customers and promote ideas to certain groups. This can increase engagement and ultimately lead to the spread of content. Sales strategies on Facebook aim to promote greater interaction with content by establishing connections with potential customers using rich and far-reaching media. An interactive approach enables the sharing and exchange of information, which can help build relationships with people, increase interaction, and generate content that influences decision-making (Tsimonis and Dimitriadis, 2014).

These findings could aid in the development of methods and models to identify false or misleading content and assess its dissemination through social networks. Researchers and dental professionals should remain vigilant about the spread of false information on toothache and should improve communication with patients. The democratization of health information through digital means underscores the importance of electronic literacy and the dissemination of high-quality oral health information to counteract the spread of information disorder. Furthermore, it is important to formulate guidelines and laws to control and combat the spread of false information, which can negatively impact people's quality of life. Developing post-screening and detection mechanisms for misleading content before dissemination can also help mitigate its negative effects.

Some limitations of this study warrant acknowledgment. First, our analysis was confined to posts in the English language, potentially constraining our comprehension of cultural nuances and distinctive linguistic features that may influence factors associated with toothache information dissemination. Second, we considered only one social media platform, introducing an inherent bias. Nevertheless, a comprehensive exploration of Facebook content recognized its prominence as a platform with a substantial user base that actively engages with health-related topics (Sharma *et al*., 2017). Third, the sample size of our study was constrained, reflecting the challenges inherent in content analysis via human evaluation. Pragmatic considerations required a judicious approach to manual data classification, aligning with established methods (Heaivilin *et al*., 2011).

In conclusion, there are a concerning number of toothache-related posts with misinformation on Facebook. This misinformation is associated with positive sentiments and financial motivation. In addition, the detection of links, videos, and positive sentiments awakened greater user interest in engaging with toothache-related posts. Therefore, the development of specific policies to improve the quality of information on social media is necessary. Additionally, digital solutions that can check the accuracy of information before dissemination and can promote digital health literacy should be encouraged. These data highlight the importance of addressing the spread of misinformation related to oral health on social media and of taking steps to ensure that accurate and reliable information is readily available to the public.

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