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Evaluating Online Fluoride Safety Information: Quality, Readability, and Misinformation Across Web Browsers

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ABSTRACT

When the public searches internet websites for dental information, they are often presented with websites with advertisements, and misinformation as well as with needed health information. The purpose of this research is to assess internet website returns for information regarding fluoride safety. Google Chrome®, Mozilla Firefox®, and Microsoft Bing® were the web browsers that were used with key words "fluoride safety." From each web browser, the top 20 returned results were evaluated (n=60). The quality of the remaining articles was evaluated with the SMOG readability criteria, the 4-point Journal of the American Medical Association (JAMA) criteria, and a 13-point Ensuring Quality Information for Patients tool that was modified for the topic of fluoride safety (MEQIP). The mean JAMA quality criteria score for the 37 unique returns was 2.3 (SD, 1.0). The mean MEQIP score for the 37 unique returns was 9.5 (SD, 1.9). The minimum score was 4 and the maximum score was 12. The mean SMOG grade-level readability score for the 37 unique returns was an equivalent grade level of 14.7 (SD, 2.9). The minimum SMOG score was grade 9.3. The maximum SMOG score was grade 21.4. The articles were all similar in reading difficulty. The rank of return of the article was not significantly associated with any quality criteria. The results of this research indicated that the reading grade level was consistently at a high level and the quality needed improvement.

Keywords: Fluoride safety, Health literature, Website, Web browsers

1 INTRODUCTION

The U.S. Federal Communications Commission (FCC) has oversight of telecommunication broadcast services (like radio and television) to balance free speech protection and restrictions on harmful content that would threaten public safety. There are different interpretations and policy debates whether the internet and social media fall under its oversight. This debate reflects ongoing discussions about the appropriate scope of federal oversight in the digital age, concerning misinformation, content moderation, and the protection of public health and safety[1, 2]. Legal and policy debates underscore the tension between the debate between free speech and countering misinformation by ensuring content accuracy without infringing on constitutional rights[3]. The extent of the FCC role is yet to be determined.

In the meantime, the internet is a primary source of health information for both laypersons and healthcare professionals. Data indicate 64.8% of individuals use the internet as their first source of health information, and 69.8% - 81.5% have used it for health-related queries[4, 5]. However, the majority of health websites do not meet high standards for accuracy or reliability[5]. Governmental and academic websites provide higher quality information, but overall, the internet is suboptimal for reliable health information[5, 6].

The World Health Organization (WHO) indicated false information is approximately 70% more likely to be shared online than accurate information[7, 8]. This phenomenon is evident in the context of fluoride and community water fluoridation (CWF), where online content is characterized by high volume, redundancy, and variable quality[6, 9-11]. Studies of social media platforms such as Instagram and X documented that false/misleading fluoride-related content is frequently produced by regular users motivated by social, psychological, or financial interests[9, 11]. Analyses of web search results reveal that while pro-fluoridation sources may receive more hyperlinks from other sites, anti-fluoridation sentiment continues to maintain significant visibility and influence online. The overall network

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structure allows anti-fluoridation perspectives to persist and circulate widely, leaving users with poorly referenced information, unsubstantiated claims and anecdotal reports[6, 10-13, 15]. The American Academy of Pediatrics and recent systematic reviews reaffirmed that CWF and topical fluoride applications are safe and effective, with the only well-established risk being dental fluorosis at excessive exposures[13-16].

There is a need for surveillance and proactive engagement by health professionals to counteract misinformation and support informed decision-making[9, 13, 17, 18]. Strategies to share evidence-based health information online are urgently needed. Therefore, the purpose of this research is to assess online data quality for information about fluoride safety.

2 METHODS

Ethical Statement

The West Virginia University Institutional Review Board acknowledged the research as non-human subject research (Protocol number 2403935225).

Data source

Data collection occurred in June 2025 with Google Chrome®, Mozilla Firefox®, and Microsoft Bing® and the key words "fluoride safety." The first 20 results from each web browser were examined (n = 60 articles) as previous research indicated most searches do not go beyond the first or second web page. Exclusion criteria were articles identified as predatory/malicious sites by NortonLifeLock™ (Symantec Corporation, Tempe, AZ).

Measures

Quality assessment involved using 3 tools: Simple Measure of Gobbledygook (SMOG) for reading grade level; a 13-point Modified Ensuring Quality Information for Patients tool (MEQIP) to address fluoride safety; and the Journal of the American Medical Association (JAMA) benchmark criteria (scores from 0-4) for quality information in website articles (points are awarded for inclusion of authorship, attribution for the source, disclosures/conflicts of interest, and date of development/revision) (Table. 1).

Statistical analysis

The IBM SPSS® version 29 (Armonk, NY) and Microsoft Excel 2024® were used to determine mean MEQIP scores, JAMA quality criteria scores, and SMOG scores. A non-parametric, Kruskal-Wallis test was used to compare the web browsers' returns on these quality assessment tools. Additionally, the correlation of the returned website's scores were compared with the rank of the return using Kendall Tau non-parametric beta correlations.

3 RESULTS

When the search term was used, the web browser indicated descriptively that there were about 73,400 returns using Mozilla Firefox®, 55,300 returns from Microsoft Bing® and 47,900 returns from Google Chrome®. (This information provides context but is not analytically relevant.)

Table 1: Criteria for the Modified Ensuring Quality (Fluoride) Information for Patients

Modified Ensuring Quality Information for Patients' Tool to Access Information on Fluoride Websites Criteria	Scoring (Possibles scores: 0-13)
Content Domain (Website includes):	
Definition/description	1= present; 0= absent
Risks	1= present; 0= absent
Benefits	1= present; 0= absent
Quality of Life	1= present; 0= absent
Identification Domain (Website includes):	
Authors' names	1= present; 0= absent
Date of issuance/revision	1= present; 0= absent
Conflict of interest statement	1= present; 0= absent
References/evidence	1= present; 0= absent
Structure Domain (Website includes):	
Average sentence lengths of less than 15 words	1= present; 0= absent
Clear writing	1= present; 0= absent
Balanced	1= present; 0= absent
Logical presentation	1= present; 0= absent
Clear figures/graphics/layout	1= present; 0= absent

The first 20 returns of each of the web browsers were analyzed as the study sample (n=60). Of the 60 returns, 37 (61.7%) were unique, 21 (35%) were duplicates and 2 (3.3%) did not involve fluoride safety (Table. 2).

Description of the 37 unique returns

The mean JAMA quality criteria score for the 37 unique returns was 2.3 (SD, 1.0). For the quality criterion of authorship, there were 12 (32.4%) unique returns with authors; for affiliation, there were 35 (94.6%) returns; for conflicts of interest, there were 6 (16.2%) returns, and for the JAMA quality criterion for the presentation of date of creation/revision, 35 (94.6%) had a date. Of these, the dates were from 2016 to 2025. The mean year was 2023, and the mode was 2025. The year 2025 had 17 of the 37 unique returns with a date (45.9%).

Three of the unique returns (8.1%) had all JAMA criteria. The returns with all JAMA quality criteria were scientific, peer-reviewed articles from PubMed.

Table 2: Returned Result Ranks of the Searches on Key Words "Fluoride Safety"

Rank	Bing®	Firefox®	Google Chrome®
1	AI generated, not peer-reviewed	Applicable, and peer-reviewed	AI generated, not peer-reviewed
2	Applicable, and peer-reviewed	Duplicate of Bing® 3	Applicable, governmental source, not peer-reviewed
3	Sponsored by a clinic and had information, not peer-reviewed	Duplicate of Bing® 4	Applicable, governmental source, not peer-reviewed
4	Applicable, from a journal, not peer-reviewed	Duplicate of Bing® 5	Duplicate of Bing® 6 and Firefox®5
5	Applicable, from a health online service, not peer-reviewed	Duplicate of Bing® 6	Applicable, information from a university, not peer-reviewed
6	Applicable, from an online health news service, not peer-reviewed	Applicable, information from a society, not peer-reviewed	Duplicate of Bing® 4 and Firefox®3
7	Applicable, governmental organization, not peer-reviewed	Duplicate of Bing® 11	Duplicate of Bing® 13 and Firefox®13
8	Applicable, information from a university, not peer-reviewed	Applicable, governmental source, not peer reviewed	Duplicate of Bing® 11 and Firefox®7
9	Applicable, information from a society, not peer-reviewed	Duplicate of Bing® 7	Applicable, from a society, not peer reviewed
10	Applicable, from a health online service, not peer-reviewed	Duplicate of Bing® 10	Duplicate of Firefox® 19
11	Applicable, from a society, not peer-reviewed	Duplicate of Bing® 9	Duplicate of Firefox® 6
12	Applicable, and peer-reviewed	Duplicate of Bing® 12	Applicable, news article, not peer-reviewed
13	Sponsored by a clinic and had information, not peer-reviewed	Duplicate of Bing® 13	Duplicate of Bing®8 and Firefox® 17
14	Applicable, from a health online service, not peer-reviewed	Duplicate of Bing® 14	Applicable, from a society, not peer-reviewed
15	*Not applicable, news article*	Applicable, and peer-reviewed	Applicable, from a society, not peer-reviewed
16	Applicable, governmental source, not peer-reviewed	Applicable, and peer-reviewed	Applicable, from a society, not peer-reviewed
17	Applicable, from a society, not peer-reviewed	Duplicate of Bing® 8	Duplicate of Firefox® 8
18	Applicable, from a society, not peer-reviewed	Duplicate of Firefox® 16	Applicable, from a society, not peer-reviewed
19	*Not applicable, news article*	Applicable, governmental source, not peer reviewed	Applicable, governmental source, not peer-reviewed
20	Applicable, from a society, not peer-reviewed	Applicable, from a society, not peer-reviewed	Applicable, from a society, not peer-reviewed

Note: The numbers 1 to 20 indicate the priority of the returned website. Rank 1 indicates the first listed website, rank 2 indicates the second, and so forth.

Table 3: Quality Criteria

	MEQIP[1]	JAMA[2]	SMOG[3]
	Mean (SD)	*Mean (SD)*	*Mean (SD)*
Mozilla Firefox®	10.2 (2.0)	2.9 (0.7)	14.6 (2.4)
Microsoft Bing®[4]	10.0 (1.6)	2.4 (1.0)	14.4 (3.1)
Google Chrome®	8.8 (1.8)	2.1 (0.7)	14.3 (2.7)

[1]*Kruskal-Wallis test for MEQIP criteria, p=0.013 with two significant post-hoc pairwise comparisons (between* Google Chrome® *and Microsoft Bing®, p=0.042, with Bing® scoring higher and between* Google Chrome® *and Mozilla Firefox®,p=0.013 with Firefox® scoring higher)*

[2]*Kruskal-Wallis test for JAMA quality criteria, p=0.014 with one pairwise significant post-hoc result (between Google Chrome® and Mozilla Firefox®, p=0.011, with Firefox® returns scoring higher)*

[3]*Kruskal-Wallis test for SMOG, p=0.773*

[4]*Two non-applicable news articles were removed from Microsoft Bing® analysis*

Table 4: Correlations of Articles' Rankings and the Articles' Quality Criteria, *n*=58[1]

	MEQIP		JAMA		SMOG	
	***r* (95% CI)**	***p*-value**	***r* (95% CI)**	***p*-value**	***r* (95%CI)**	***p*-value**
Mozilla Firefox®	-0.06 (-0.37, 0.26)	0.734	-0.15(-0.44, 0.17)	0.418	-0.04 (-0.28, 0.35)	0.820
Microsoft Bing®	-0.21 (-0.49. 0.11)	0.226	-0.23(-0.52, 0.11)	0.223	0.03 (-0.32. 0.36)	0.879
Google Chrome®	-0.11 (-0.41, 0.21)	0.527	-0.17(-0.46, 0.15)	0.351	-0.23 (-0.51, 0.09)	0.153

[1]*Two non-applicable news articles were removed from Microsoft Bing analysis®*

[2]*Kendall Tau non-parametric beta correlations*

The mean MEQIP score for the 37 unique returns was 9.5 (SD, 1.9; minimum 4; maximum 12). The mean SMOG grade-level readability score for the 37 unique returns was grade level of 14.7 (SD, 2.9; minimum 9.3, maximum 21.4) (Table. 3).

For Mozilla Firefox®, the mean JAMA quality score was 2.9 (SD, 0.7), the mean MEQIP was 10.2 (SD, 2.0) and the mean SMOG was 14.6 (SD, 2.4). For Microsoft Bing®, the mean scores were 2.4 (SD, 1.0), 10.0 (SD, 1.6), and 14.4 (SD, 3.1), respectively. For Google Chrome®, they were 2.1 (SD, 0.7), 8.8 (SD, 1.8), and 14.3 (SD, 2.7), respectively.

The Kruskal-Wallis non-parametric test for JAMA quality was significant, p=0.014. In one pairwise post-hoc result Firefox® scored higher than Google Chrome® p=0.011. The Kruskal-Wallis non-parametric test for MEQIP was significant, p=0.013. In post-hoc pairwise comparisons, Microsoft Bing® scored higher than Google Chrome®, p=0.042 and, Firefox® scored higher than Google Chrome®, p=0.013). The Kruskal-Wallis test for SMOG failed to reach significance, p=0.773.

The Kendall's tau non-parametric beta correlations are presented in Table. 4. There were no significant correlations of the rank of the returned article and quality. For the correlation of the rank of the returned articles and the JAMA quality criteria for Mozilla Firefox®, Microsoft Bing®, and Google Chrome®, the p-values were 0.418, 0.223, and 0.351, respectively. For the rank of the returned articles and the MEQIP, the p-values were 0.820, 0.879, 0.153, respectively. And for the rank of the returned articles and the SMOG score, the p-values were 0.734, 0.226, and 0.527, respectively.

4 DISCUSSION

In this quality assessment analysis, the rank of internet search return was not significantly associated with quality. There were articles of higher quality throughout the 20 returned articles for each web browser. The reading level for all returns was an overall grade level beyond high school education (14.7). Authorship identification was low (32.4%) although affiliations were noted in most (94.6%). Posted returns were relatively current.

In our analysis, only 37 unique websites were identified among the first 20 search results from each web browser. Duplicate presence in top-ranked sites highlights high redundancy in online content, and concerns about the breadth of public accessible perspectives. Despite the proliferation of online health information, content on fluoride safety remains largely superficial[6, 12].

Only a minority of sites met all JAMA criteria. Statistically significant differences were observed across web browsers, with Bing® and Firefox® producing higher-quality content than Chrome®, though no significant correlation emerged between search result ranking and information quality. These findings align with previous studies noting that web browser algorithms do not consistently prioritize the most credible[19, 20].

The lack of depth, transparency, or robust referencing, limits content utility for informed clinical decision-making and public understanding[6, 12]. Even among pro- and neutral-fluoridation sites, which scored higher on credibility, comprehensive evidence-based discussions were often missing[6, 13]. Moreover, readability analyses, particularly those using the SMOG index, demonstrate that many health websites exceed the recommended reading level, potentially alienating audiences with limited health literacy[10, 22, 23]. The structure of the online information ecosystem further exacerbates these limitations. Misinformation is not only widespread but is actively amplified by search algorithms and social media platforms[9, 12, 14]. The discontinuation of third-party verification mechanisms such as the Health On the Net Foundation has contributed to the challenge of distinguishing credible from non-credible sources. Misinformation, especially when packaged as visually compelling and emotionally resonant, can undermine public trust and dilute evidence-based public health messaging[9, 14, 15].

Policy implications and future research

Our findings reinforce the importance of improving the transparency, depth, and scientific rigor of online fluoride-related content. In areas with low literacy, it is even more important that health information is available at an appropriate grade level. As misinformation continues to challenge public health guidance, clinicians and public health professionals must remain proactive in guiding patients toward high-quality, evidence-based information verified by credible sources. It is also important to develop a standardized set of guidelines for healthcare providers in communicating to the patients about the use of such content on the internet. Furthermore, there is a pressing need for authoritative, user-friendly platforms that reflect both the preventive benefits and the evolving risk considerations of fluoride exposure. These platforms should integrate current scientific findings with clear, accessible language to support informed decision-making and protect public health. In addition, local and state public health agencies need to be supported with more resources, so they can effectively address misinformation.

Strengths and Limitations

This study has a few limitations. First, the search in this study was conducted in June 2025. However, information on the internet is constantly updated and may influence the ranking of search results. Therefore, a new search may show some variance in results if the information has changed. Another limitation rests with the measures used. For example, SMOG or any other readability measure cannot assess whether the reader has understood the content[24]. The JAMA benchmark criteria are unable to assess the medical validity and primarily focus on transparency and trustworthiness of the source[25]. In addition, the evaluation by JAMA scores may be influenced by subjective bias of the reviewer[25]. Lastly, our search was limited to the top 20 searches for each web browser and only evaluated written online materials.

Our study has several strengths. First, we used multidimensional methodology for evaluating the quality of online information available on fluoride safety. We used three measures for this evaluation. SMOG is an easy and quick tool to estimate a printed communication's reading grade level. Another measure, MEQIP, has been widely used as a robust and effective tool to assess patient information. Lastly, our search was not limited to one web browser, but we used three most used web browsers to be representative of the overall search returns.

5 CONCLUSION

This study demonstrated that although the internet is a primary source of fluoride safety information for both professionals and the public, the readability and content quality of these resources need improvement. Online health information written above recommended reading levels often lacks depth and accuracy, which can impede informed decision-making and public health communication efforts.

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