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Fluoride in Visual Culture: How Art, Design, and Artificial Intelligence Shape Public Perceptions of Public Health?

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ABSTRACT

Purpose: The intersection of fluoride (F), visual culture, art, design, and artificial intelligence (AI) provides a unique strategy for assessing public perceptions of human health. Fluoride, recognized for its role in dental health, has also sparked controversy and misinformation, shaping public discourse around chemical interventions in daily life.

Methods: The present article investigates the impact of visual culture expression, design practices, and AI generated media on societal understanding and acceptance of F in public health policies.

Results: From mid-20th-century public health posters to contemporary data visualizations and social media narratives, visual representations have significantly shaped perceptions of F as either a beneficial or harmful substance. The era of AI generating health-related content further complicates this landscape, presenting opportunities for proper communication and risks of algorithmic bias and misinformation. Drawing on interdisciplinary perspectives from art history, visual design, public health, and digital ethics, this paper critically analyzed how visual culture shapes collective attitudes toward F and similar public health interventions.

Conclusions: It concludes with recommendations for ethically leveraging the design and AI-promoted science-based public engagement. Visual culture plays a significant role in public health by making scientific information accessible, engaging, and impactful, ultimately contributing to improved public health outcomes. Interdisciplinary collaboration with designers, AI experts, and public health professionals can be essential to ensure that these innovations are ethically sound and more impactful for better future.

Keywords: *Artificial intelligence; Fluoride intake; digital health, Visual scientific core; Human supervision; Public health education*

INTRODUCTION

Fluoride (F) has played a crucial role in public health, especially in preventing cavities and enhancing oral health. Since its introduction to community water supplies in the mid-20th century, F has been one of the past century's most significant public health achievements, yet also criticized as one of the community's biggest failures. WHO and CDC recommended optimal F exposure as a safe, practical, population-based approach to preventing dental caries.[1,2] However, the widespread implementation of water fluoridation programs has sparked considerable controversy with some harmful effects, such as dental and skeletal fluorosis, as well as systemic complications.[3]

Within this context, visual culture, which encompasses art, design, media, and digital technologies, has been pivotal in shaping how the public understands, assimilates, or rejects scientific knowledge about F.[4] This evolution commenced with the first government-issued posters endorsing fluoridation and transitioned to contemporary infographics appearing on social media. These infographics illustrate that not only this information has been rendered "graphical" in the literal sense, but it has also been given a visual form, in many cases, conveys ideology as well as information.[5] The emergence of AI

Figure 1. Public health depends on relevant part of their knowledge and methodological tools in different scientific areas

and algorithm-based content generation has further complicated this landscape, leading to the rapid adoption of evidence-based narratives alongside the spread of misinformation through visually appealing.[6] As AI-driven tools increasingly mediate access to health-related knowledge, the ability to discern and interpret visual strategies through F becomes vital for analyzing broader patterns of public engagement with science.[7,8]

This review examines the dynamic intersection of F, visual culture, and public health communication, critically evaluating how artistic expression, design innovation, and AI-generated visuals influence public perceptions of F risks and benefits. By drawing on insights from diverse fields, i.e., media studies, visual rhetoric, science communication, and digital ethics, this paper aims to develop nuanced understanding of visual culture as conduit and battlefield for public health discourse. Ultimately, it underscores the imperative of responsible visual communication in shaping science-based decision-making and advances ethical frameworks for harnessing design and AI in future public health strategies (Figure 1).

HISTORICAL CONTEXT: FLUORIDE AND PUBLIC HEALTH

At the dawn of the 20th century, the first scientific evidence of the dental benefits of F and its significance was shown in the context of public health and preventive medicine.[9] In the 1930s, scientists observed that people living in various regions of the United States, such as Colorado and Texas, developed mottled enamel on their teeth but had significantly fewer cases of dental caries. This observation led to one of the most significant discoveries regarding the natural properties of F. This element strengthens and enhances the enamel of the teeth, making it more resistant to acid erosion caused by oral bacteria.[10] By the early 1940s, systematic research had demonstrated optimum exposure to F, primarily through ingestion via drinking water and other ways. Reduced dental caries by 40–60% without adverse effects, such as dental fluorosis, when maintained at the recommended concentrations established through clinical and controlled trials.[11] These findings led to one of the 20th century's most significant public health interventions, the fluoridation of community water supplies. The challenge of implementing, this approach was more than just a matter of science or medicine. It was fundamentally political and communicative, requiring widespread public support and significant trust-building.[9]

Widespread adoption of water fluoridation programs by governments in 1940s and 1950s made public health messaging a major part of social constructs surrounding F. Visual propaganda effectively promoted F as a safe and effective approach for enhancing the population's oral health. U.S. Public Health Service and the American Dental Association launched extensive educational initiatives, utilizing posters, radio broadcasts, films, and other printed materials from the public.[12] The visual rhetoric was carefully crafted to align with prevailing narratives of post-war recovery, scientific progress, and national health security system.[13]

Fluoride's ideological significance intensified during the Cold War, becoming inextricably associated with broader geopolitical narratives.[9] During this period, public health officials and policymakers connected F to U.S. scientific excellence and social welfare, contrasting healthcare systems in communist nations with those in the United States. Propaganda from this era often associated F with patriotism, democracy, technology, and concern for the common good. Government-sponsored educational films presented F for the fight against diseases, with animated graphics and a persuasive narrator.[14] Anti-fluoridation organizations employed counter-imagery, framing F as a harmful substance, often linked to nuclear contamination.[15] The impact of visual strategies continues to resonate in the present debates of F, reflecting the enduring power of imagery and rhetoric in shaping public understanding of science and health policy (Figure 2).

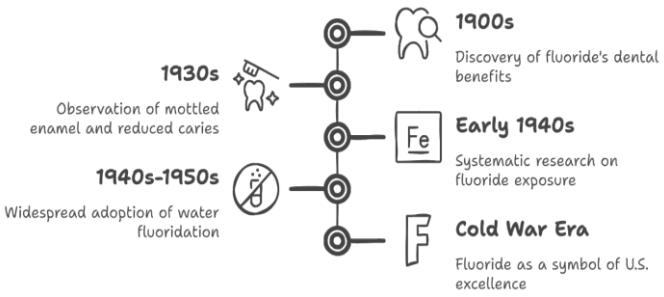

Figure 2. Evaluation of fluoride in public health

ART AND THE REPRESENTATION OF SCIENCE

The arts-and-science interface has always been a rich source for imaginative investigation, public discourse, and critical discussion, especially in the health sciences, e.g., as exemplified in the fluoridation debate. Over the past few decades, environmental and conceptual artists have made it one of their primary objectives to use science as a cultural arbiter, particularly regarding chemical alteration in public spaces and human body.[16,17] Its addition to public water supplies, an accomplishment initially portrayed as a victory of preventive medicine, has also become the subject of artistic condemnation of the power of scientific authorities and the morality of mass chemical exposure without informed personal consent. Contemporary artists have employed F as a material and metaphor during installation, performance, and multimedia projects to investigate themes of control, monitoring, and health politics.[9]

The material and symbolic exploration of F in culture and society has been associated with conceptual and environmental art strategies.[18] However, artists and ecological art pioneers, i.e., Helen Mayer Harrison and Newton Harrison, have assessed this complex aspect of intervention and its broader implications for natural systems, including the chemical treatment of water resources. Their work often incorporates scientific studies and visualizations that illustrate the interconnections between ecosystems and unintended effects of technological responses.[19] In the case of F, some artists participate by constructing architecture-scale, site-specific installations, such as replicating the structure of brick water treatment plants or using fluoridated materials to create sculptural forms, which aim to make “visible” this invisible but ubiquitous supplement in our daily lives.[16] Moreover, ecological art engages with F is deeply intertwined with broader issues of water and justice, and corporate control over public health, and the bodies are commodified and subject to exploitation by the pharmaceutical and chemical industries.[20]

Resistance to medical authority and chemical intervention are the centre of various artistic treatments of F. The history of water fluoridation is closely associated with Cold War narratives of scientific authority, national progress, and civic responsibilities.[21] However, these narratives are countered by artists who condemn top-down health agendas and non-acceptance of chemical solutions to complex social problems. For example, as an artists' collective, the Critical Art Ensemble unpacks in their works, the bio-political manipulation embedded in public health propaganda, such as food additives. Their performative and media-based works often replicate scientific experiments or create phoney public service announcements that challenge the foundational assumptions of state-sponsored health interventions. By employing the aesthetics of science communication, including charts, diagrams, and clinical settings. These artists question the authority of medical institutions and encourage viewers to reassess the evidence supporting public health initiatives.[22-24]

Single-artist case studies exploring health themes reveal the complexity and variety of artistic responses to F, and its related discourses. It includes the work of Mary Maggie, whose biohacking practices investigate the intersection of gender, hormones, and environmental toxins. Similarly, artist Miriam Simun has envisioned design scenarios that critically address the future of food and medicine. These artistic practices enhance our understanding of how science is balanced and contested in the public sphere. Visual culture is crucial in constructing knowledge and informing understanding, as it annotates and challenges dominant discourses.[25] As aesthetic experiences and critical commentaries, artistic representations of F encourage audiences to reevaluate their relationships with scientific authority, chemical exposure, and collective deliberation. Furthermore, the pervasive nature of digital and interactive media in contemporary art can foster more profound and engaging participation in these issues. Augmented reality displays, data-driven visualizations, and crowd-sourced mapping projects provide audiences with opportunities to explore patterns of F distribution, visualize health determinants, and even model policy.[17] These tools enhance the public understanding of complex scientific issues and create opportunities for more inclusive discussions about the risks, benefits, and consent involved in developing public health interventions.[24,26]

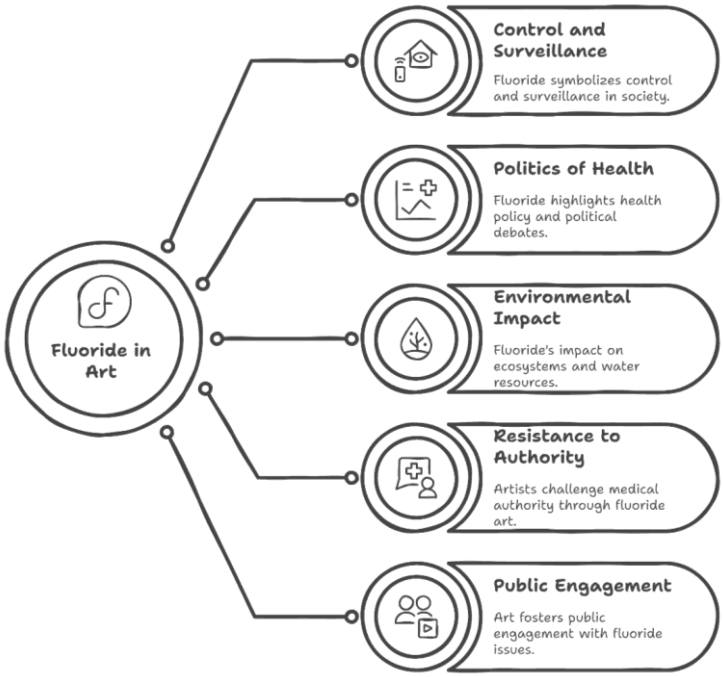

Figure 3. Exploring fluoride through artistic lenses

The depiction of F in art and visual culture reveals multiple layers through science is interpreted, contested, and reimagined by artists and the broader public. From philosophical critiques of medical authority to material explorations of environmental chemistry, artists continually challenge conventional frameworks for understanding science and translating knowledge into action.[9,22] Their work underscores the necessity of interdisciplinary discussion among the arts, sciences, and humanities to address pressing ethical and epistemic concerns, i.e., the role of chemical interventions in public life.[24] As emerging technologies and media evolve, the art world's engagement with science further informs public policy debates on health, perception, and societal values (Figure 3).

DESIGN AND COMMUNICATION STRATEGIES

Design and communication strategies are crucial in shaping public perception, understanding, and acceptance of scientific and health-related information. In public health, particularly regarding F use, vaccination programs, and environmental toxins, visual communication tools, like infographics, posters, and digital media, convey factual data and frame narratives that influence behaviour and policy outcomes.[27,28] When effectively implemented, these design elements can simplify complex scientific concepts, enhance message retention, and foster trust between institutions and public. However, poorly executed or intentionally manipulated can contribute to misinformation, confusion, or even resistance to public health initiatives.[22]

Infographics have become one of the most widely used tools in modern public health communication due to their ability to condense large volumes of data into visually digestible formats.[29] A well-designed infographic leverages visual hierarchy, iconography, and minimal text to convey key findings quickly and clearly. For example, during the early promotion of water fluoridation in the United States, public health agencies utilized compelling infographics that displayed side-by-side comparisons of teeth with and without decay, often accompanied by statistics on reduced caries rates. These visuals were persuasive because they presented clinical data as tangible, relatable benefits for the average citizen.[7,9] In contrast, anti-fluoridation campaigns have also employed infographics to highlight potential risks, using color-coded graphs and alarmist imagery to suggest correlations between F exposure and adverse health outcomes. The effectiveness of these materials underscores how the same medium, infographics, can be used to promote evidence-based policies and spread scientifically unfounded concerns.[30]

Posters, especially those designed for educational or awareness campaigns, remain relevant in traditional and digital formats. Historically, government-issued posters played a significant role in public health messaging, particularly during the mid-20th century.[31] In the case of F, posters from the 1950s often depicted smiling children with healthy teeth, reinforcing the notion that fluoridation was safe and beneficial practice.[17] These posters utilized bold typography, clean layouts, and carefully chosen color schemes to evoke trust and optimism. In contrast, more recent anti-fluoride posters have adopted a distinct aesthetic,

employing darker colors, jagged fonts, and ominous imagery to convey a sense of urgency and danger surrounding F consumption. This divergence in design choices illustrates how typographic and visual elements are deliberately selected to shape emotional responses and reinforce ideological positions.[32]

Digital media has transformed public health communication by enabling real-time interaction, personalization, and the widespread dissemination of information. Social media platforms, websites, and mobile applications are primary channels for individuals accessing health-related information.[33] Organizations, like the Centers for Disease Control and Prevention (CDC) and the World Health Organization (WHO), utilize animated explainers and interactive maps to visualize disease outbreaks, vaccine coverage, and chemical exposure risks. During F education, such tools can provide personalized risk assessments, regional water quality reports, or myth-busting quizzes that cater to diverse audiences.[34,35] However, the same digital landscape also allows for the rapid spread of misinformation. Viral posts featuring misleading visuals, like images of industrial waste being falsely labelled as "fluoride," can gain attraction quickly, especially when shared within echo chambers where critical evaluation is limited. This dual-edged nature of digital media necessitates a heightened emphasis on ethical design practices and fact-checking mechanisms.[22]

Typography, color, and layout are fundamental to any visual communication strategy, significantly influencing how messages are received and interpreted. Typography significantly impacts readability and tone. In public health campaigns, legibility is crucial, especially when targeting older adults or populations with varying literacy levels.[36] Color psychology also plays a vital role, such as blue tones often evoke trust and calmness, and red signifies urgency or warning. Green is commonly linked with health and safety. Layout design further enhances comprehension by organizing information logically, ensuring that the viewer's eye moves naturally from headline to supporting details to call-to-action statements. Misuse or neglect of these design principles can lead to misinterpretation or disengagement, regardless of the accuracy of the underlying message.[37]

Analyzing successful and controversial design campaigns reveals essential lessons about using visual rhetoric in public health. Successful campaigns typically share clear messaging, emotional resonance, and cultural sensitivity.[9,13] For instance, the "Truth" campaign against smoking in the U.S. employed edgy, youth-oriented visuals and strong calls to action that resonated with its target demographic, resulting in measurable reductions in youth smoking rates. Similarly, the WHO's handwashing campaign during the COVID-19 pandemic utilized vibrant illustrations and multilingual signage to promote hygiene across diverse populations. Conversely, controversial campaigns often suffer from poor design execution or deliberate fact manipulation. Such campaigns exploit visual persuasion techniques to erode public trust in science, underscoring the requirement for enhanced design literacy among creators and consumers of health-related content.[38,39]

Design and communication strategies are indispensable tools in public health, enhancing knowledge dissemination, fostering behavioural change, and building institutional credibility. Infographics, posters, and digital media offer unique advantages in engaging different audiences.[23] While many campaigns have successfully leveraged these tools to promote health literacy and preventive care, others have demonstrated how visual design can be weaponized to distort scientific consensus and fuel public anxiety. As health issues become increasingly complex and politicized, designers, public health officials, and policymakers must collaborate to create transparent, accurate, and ethically responsible visual communications that empower the public.[32,36] Future research should investigate how emerging technologies, like AI and augmented reality, can be effectively integrated into design strategies to further personalize and optimize health messaging (Figure 4).

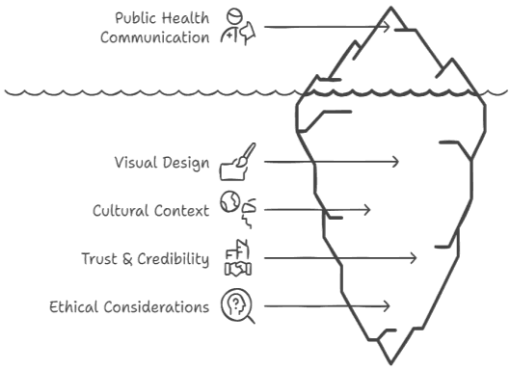

Figure 4. Communication in the public domain

ARTIFICIAL INTELLIGENCE AND DIGITAL MEDIA INFLUENCE

With the emergence of AI technologies and increasing prevalence of digital media, health information generation, dissemination, and consumption have transformed beyond recognition. Specifically, AI-assisted content creation tools, such as natural language processing models and image generation algorithms, have disrupted public health communication, especially around controversial topics, such as F application and use. These technologies drive the automation of article writing, infographics, videos, and social media posts, reaching millions of people in seconds.[40] This can enhance scientific literacy and mobilize evidence-based messaging about health. However, it presents the risks of misinformation, algorithmic biases, and reduced trust in scientific institutions. The influence of AI-generated content on health narratives is increasingly evident in the debate surrounding F, with supporters and detractors of fluoridation using AI-generated tools to amplify their articulated messages, often without disclosing authorship or intent.[22]

One notable trend in this respect is large language models (LLMs) and generative adversarial networks (GANs) can produce compelling, visually grounded content, often indistinguishable from expert communication. For instance, AI systems can now automatically produce elaborate reports, charts, and even peer-reviewed-style summaries that appear unquestionably authoritative, lacking rigorous scientific validation. When it comes to F, these tools are being put to work by advocacy groups to create media that supports or counters public health orthodoxy or at least presents a different spin on the science. This duality of AI content has made the information ecosystem more challenging to navigate partisan sites and seek accurate, truthful information. Moreover, as AIs are trained on real-world datasets, they can mimic biases encoded in these datasets, either reproducing existing prejudices or exacerbating already polarized views.[41,42] The artificially generated voices have the potential to unduly influence public opinion, creating the illusion that a position is popular and applying unnecessary pressure to policy-making decisions and local community debates.[43]

In light of these challenges, ethics must be truthful in developing and implementing AI-powered public health communication. AI researchers and platform builders are crucial in preventing the spread of harmful misinformation, particularly in areas that significantly impact public health. Quick steps they have taken include introducing strong fact-checking systems, elevating respected health organizations in search results and recommendations, and offering users contextual warnings when they encounter unfounded claims.[44]

The important ethical dimensions are the requirement for inclusiveness and cultural competency in AI for health communication. Debates over F are not uniform everywhere. The issue of debate varies according to local history, social class, and the level of trust in government institutions. AI must be trained on diverse datasets that capture these variations rather than relying on a one-size-fits-all model for everyone. Moreover, participatory design approaches to AI, where affected communities are integrated into the design and implementation of AI tools, can contribute to ensuring that digital health interventions are actionable and sensitive to local concerns.[8,45]

The convergence of AI and digital media has revolutionized the public health communication landscape, presenting unprecedented opportunities and threats. While AI-generated content represents a highly scalable and personalized messaging tool, it needs to be effectively governed to prevent the propagation of misinformation and the erosion of public trust. Social media has developed to appeal the user's psychology. However, it has become a trade-off with truth regarding issues, such as the use of F. Ethical considerations, including transparency, accountability, inclusivity, and equity, should inform the integration of AI into health communication frameworks. As the field of AI evolves, strategies for ensuring these technologies contribute to the public good, support informed decision-making, and uphold the integrity of the scientific discourse in the digital age.[46,47]

CONCLUSIONS AND FUTURE PROSPECTIVE

The exploration of F as a visual culture-spanning art, design, and AI reveals that public attitudes toward public health are not shaped solely by data or government policy but constructed through visual narratives. From mid-century public health posters glorifying F as a "miracle mineral" in the fight against tooth decay to contemporary digital artworks questioning its safety and efficacy. Imagery has played a pivotal role in shaping perceptions of public health measures. Visual culture has played a crucial role in shaping how we perceive and incorporate public health measures into our everyday lives. No one has understood this potential more deeply than graphic designers. The networks that share creative images promoting F-containing products can also be used to develop compelling anti-F arguments, and the boundary between evidence-based information and emotionally charged misinformation becomes obscured. Art intervention has added complexity to the narrative, providing critical viewpoints against the prevailing public health authority. Installations, films, and performances have scrutinized the ethical implications of mass medication, the politics of city water systems, and the legacy of chemical interventions in everyday life.

Develop engaging, evidence-based visual campaigns that counter misinformation while maintaining emotional resonance, and collaborate with artists and designers to create compelling narratives that bridge scientific accuracy and public engagement. Educate the public on interpreting visual rhetoric in health messaging to distinguish between evidence-based content and manipulative imagery. Investigate the role of social media algorithms in amplifying pro- or anti-F visual content for better future.

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None

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