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Understanding Fluoride's Influence on Mental Health: AIGC Educational Methods for Undergraduate Students

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ABSTRACT

Purpose of the Study: This study examines the perceived effects of mental health from fluoride exposure among college students within fluoride endemic regions of China and evaluates the effectiveness of AI generated content (AIGC) as a teaching tool for raising awareness of such effects. We aim to close knowledge gaps in environmental health literacy and test AIGC's potential to expand understanding of complicated health matters.

Method: This adopted approach was a qualitative one and the focus group discussions with 20 college students in fluoride endemic regions. The AIGC materials consisted of infographics, animations and interactive modules to explain fluoride's mental health effects to the participants. Data were analyzed thematically to provide patterns of recurring problems of perceptions associated with mental health, educational effectiveness, and accessibility.

Findings: Participants felt there was a link between fluoride exposure and anxiety, cognitive problems and emotional instability. Awareness of knowledge gaps increased significantly, with 90% of participants aware of knowledge gaps filled by the AIGC materials. AIGC was successful but there were some accessibility challenges found mostly in low resource settings.

Implications: Their findings emphasise the importance of targeted mental health resources in fluoride endemic regions as well as the potential of AIGC as an effective public health education tool. Future initiatives should embrace hybrid educational models in order to be inclusive and remove disparities in digital access.

Keywords: *Mental Health, AI generated content, College students,Fluoride awarness, Cognation*

1 INTRODUCTION

Fluoride exposure and its effects on mental health is an area of particular interest, and where fluoride concentrations in water and the environment exceed accepted levels. A naturally occurring chemical in drinking water, dental products and industrial emissions — fluoride has been fiercely debated as to whether it helps or harms. The use of excessive fluoride levels for public health initiatives like water fluoridation has been praised for reducing dental caries, but there is increasingly mounting empirical evidence that suggests that excess fluoride exposure carries more than its fair share of potential neurological and psychological debts [1]. College students are among the most vulnerable to such impacts, as they have many of their own unique stressors, cognitive and mental health challenges. In this case, the contribution of innovative educational tools, such as AI generated content (AIGC) in raising awareness and reducing the destructive impacts of fluoride on mental health is important.

Fluoride exposure is detrimental to our mental health, leading to anxiety, cognitive damage, emotional instability, and sometimes even depression. Particularly in regions that are fluoride endemic, high concentrations of fluoride in water are a public health concern. For example, in Pakistan, certain areas are known to have fluoride concentrations well above the recommended levels, contributing to potential health issues among the population. Similarly, in regions of China, excessive fluoride levels in drinking water have raised concerns about the long-term neurological effects on the residents. There has been little research on fluoride's neurotoxicity in specific groups, general populations, children, or on specific health outcomes like reduced IQ or neurodevelopmental delays. But there hasn't been much exploration on what effects there might be on college students who are exposed to fluoride, a group that faces heightened psychological stress due to academic, social, and personal pressures [2, 3]. However, this gap emphasizes the necessity of scrutinizing the particular psychoactive actions of fluoride on mental health among a population as this demographic particularly in nations for example China where fluoride exposure exists and is ubiquitous in few regions.

In addition, limited knowledge and awareness of fluoride risk exists among college students, and the risks are not well understood. In Pakistan, as in other countries, many students are unaware of the potential mental health impacts of fluoride exposure. Despite their levels of education, many students don't realize how fluoride could affect their mental health, or what they could do to minimize that risk [4]. Historically, though, these health information dissemination methods have been as ineffective for this audience as they are for the rest of us. That is where AIGC comes in. In this context, AIGC provides a unique opportunity to present the complex health information in a visually attractive, interactive and easily comprehensible manner. AIGC can not only educate students on fluoride's effects but also give it a methodology for dealing with these risks by using AI generated infographics, videos, and interactive modules.

1.1. Aim of the Study

In this study, we attempt to investigate the impact of fluoride exposure on mental health of college students in China, and further explore the efficiency of AIGC-based education to enhance public awareness and promote mental health. This research offers actionable insights about how to refine public health interventions related to fluoride exposure, one component of which is inadequate student knowledge, that is shared among public health policy researchers and public health educators.

1.2. Research Questions

To achieve this aim, the study is guided by the following research questions:

1. **What are the perceived mental health impacts of fluoride exposure among college students in fluoride-endemic regions of China?**
2. **How effective are AI-generated content (AIGC) educational materials in increasing awareness and promoting mental health among college students?**

1.3. Research Gap

Most of the existing literature on fluoride exposure has been concentrated on physical health effects (such as dental and skeletal fluorosis), with comparatively little focus on its psychological and cognitive effects. Studies examining fluoride's mental health effect more broadly

have tended to focus on young populations, such as children, or the adult population more widely, and have little to say about college students, a uniquely exposed and vulnerable population. Academic stress, social pressures and development of this transitional phase of life all prove to be challenging for college students, but it's still an area of research that hasn't been sufficiently explored, as it relates to how fluoride exposure compounds these mental health challenges.

Other educational interventions have been used to tackle public health issues of fluoride, but these never have the engagement or are inapplicable to tech savvy, digital blooded millennials like college students. With the emergence of AIGC comes a chance for innovation in our health education through the mediums of interactive, visually appealing, and accessible formats. Nevertheless, academic literature is almost unexposed about the application of AIGC in raising awareness on fluoride's health impacts [5, 6]. AIGC has been studied primarily in general education or marketing rather than in its application as a tool of health awareness. This research addresses these gaps with a focus on mental health impacts of fluoride exposure among college students and the assessment of AIGC as a novel educational method. First, the dual focus is not only illuminating a previously marginalized population, but also offers an inventive tool to potentially transform future health awareness campaigns.

This study combines insights from mental health, environmental science and educational technology in order to analyze fluoride exposure from a multidisciplinary point of view. This research is particularly important with reference to China, where there is a high prevalence of fluoride exposure in some regions. Many millions of people in China are afflicted with endemic fluorosis resulting from excess fluorine in drinking water and in the diet. For many college students in these regions, their exposure to poor physcial health doesn't stop there. Cognitive and psychological effects might be at risk of going unnoticed.

Educational resources in these areas are lacking, and that lack of awareness along with the lack of resources takes the pressure off students and leaves them ill prepared to even understand the problem, let alone address it. It then uses AIGC as a response to this as it can create scientifically accurate content that is tailored, engaging and uses knowledge concepts. This research examines local solutions by focusing on college students in fluoride endemic areas of China, but also provides a scalable solution for addressing similar problems on other scales.

1.4. Literature review. Fluoride exposure and mental health

Studies have examined fluoride exposure to the physical health such as dental and skeletal fluorosis. In recent years, however, its neuropsychological effects, especially upon mental health, have drawn attention. Chronic exposure to high fluoride levels may produce neurological impairment and result in symptoms including anxiety, cognitive deficit and depression, according to studies. For instance, the work of Choi et al. (2012, Grandjean & Landrigan 2014[7]) showed significant inverse associations between fluoride exposure and child cognitive performance. Although these findings suggest that fluoride is neurotoxic, the majority of studies focus on children or the general adult population, leaving college students — a population especially susceptible to psychological stress — underinvestigated. Regardless of the degree you have, college students are typically going through active transitional life stages, along with more social and academic pressure, all of which can make them more susceptible to general mental health issues. However, the impact of fluoride on cognition and emotion in this population has received little study, especially in fluoride-endemic regions such as parts of China and Pakistan. In both countries, areas with high fluoride concentrations in drinking water may contribute to potential health risks for residents, including college students. This makes it particularly important to understand the effects of fluoride exposure on the mental well-being of college students and to explore the broader implications in such regions

1.5 Awareness and Health Education

Extensive public awareness is an important way to mitigate the risks from exposure to fluoride to the health. The stress laid on educating populations who reside in fluoride affected regions about sources of fluoride, its potential risks, and ways to reduce exposure can be found in studies. For instance, Kusuma, Burman [8] discovered that a behavior change such as increased use of fluoride-free water sources occurred in fluoride end countries after awareness campaigns. People, however, are not engaging with

these methods of traditional health education such as leaflets or lectures, and they often don't engage with younger audiences who are, most likely, already tech savvy.

1.6 AI-Generated Content (AIGC) in Education

The advent of AIGC has come as a new tool to create engaging, tailored, and scalable educational content. AI technologies can create a variety of types of content from infographics to animations to videos to quizzes, all of which are especially good at capturing the interest of younger audiences. Zawacki-Richter, Marín [9] research summaries the possibilities with AIGC to simplify complex topics and increase retainment through visual rich and interactive formats. In countries like Pakistan, where certain regions suffer from high fluoride concentrations in drinking water, AIGC could be particularly impactful in raising awareness about this issue. AIGC holds the promise to infuse a bridge of awareness to action between the verbal, written, and visual information that college students are exposed to in the classroom, and the visual and media information that typically reaches them directly.

1.7 Mental Health in the Context of Environmental Stressors

The link between environmental stressors and mental health is well-documented. There has been shown exposure to pollutants, including heavy metals and other toxins, increases the risk of anxiety, depression or cognitive functioning [10, 11]. Increasingly, fluoride is being considered one of the many environmental toxins which is a contributing factor in these outcomes. Correlations between high fluoride concentrations in drinking water and an increased frequency of mental health problems have been reported from studies in fluoride endemic communities, but the mechanisms are still under investigation. Living environmental stressors, fast pace of academic pressures, and falling short on the knowledge of proper life leave college students highly vulnerable to mental health challenges. To solve this problem we need to investigate how fluoride exposure impacts and educate students through effective strategies so they can make informed choices regarding their future.

2. METHODOLOGY: FOCUS GROUP DISCUSSION

2.1. Participants and Sampling

To explore the mental health impact of fluoride exposure on college students and to assess the effectiveness of an AI generated content (AIGC) as an educational tool, we use focus group discussions as primary data collection method in this study. College students living in areas where fluoride is endemic will be participants. They propose to use purposeful sampling to first select students that meet the criteria of living in areas with high fluoride levels in water and are willing to participate. We will try to make sure that gender, discipline, and socioeconomic background of participants are diverse, enabling a number of views. Online and offline communication channels will be used to recruit participants through university networks.

2.2. Focus Group Design

Each focus group will consist of 6–8 participants, with the discussion lasting approximately 60–90 minutes. The sessions will be conducted in a neutral and private setting to provide a comfortable environment conducive to open and honest dialogue. A trained facilitator with expertise in qualitative research and health communication will moderate the discussions. The facilitator will use a semi-structured guide developed specifically for this study. The guide will include open-ended questions designed to explore students' baseline awareness of fluoride exposure, their perceptions of its potential mental health impacts, and their opinions on the design, clarity, and effectiveness of the AIGC materials.

2.3. Phases of Focus Group Discussions

The focus group discussions will be divided into two phases: post intervention and pre intervention. In the pre intervention phase, participants will speak about how much they know now about fluoride exposure and its impact on their mental health. After this, participants will be guided to the AIGC educational materials. Content of these materials will range from interactive to visual, such as infographics and animations, that will offer explanations about possible

health effect of fluoride exposure in an engaging and understandable way. Post intervention, participants will reflect upon AIGC materials and locate the impact of the content on participants' understanding of fluoride and its possible health impacts.

2.4. Data Collection

To verify the data, we got participants' consent to have audio recordings of the focus group sessions. Furthermore, detailed field notes were also taken in order to record contextual information of participant's nonverbal cues and group dynamics. It is both front and back end that guarantees the discussions are covered in their entirety with verbal and contextual inputs. Conducted in Mandarin Chinese, the focus groups will take place to make sure participants are able to speak their minds, and for professional transcription services to make accurate transcripts of the conversations.

3. DATA ANALYSIS

The transcribed data will be analysed using thematic analysis according to Braun and Clarke's six steps [12, 13]. The process will start with familiarization with the data staring with initial coding to define what particular concepts and patterns are repeated. Through grouping similar codes together, themes will be formed and reviewed, defined and named to distill the main insights of the data. A subset of the transcripts will be independently coded by a second researcher to ensure inter coder reliability and to avoid bias. We will use themes such as the awareness of participants of fluoride exposure, mental health experiences and their evaluations of AIGC materials.

3.1. Ethical Considerations

This study is critical with regard to ethical compliance. Detailed information pertaining to the objectives of study, procedures and the rights of participants in the study has been provided to all the participants prior to the focus group session. All participants gave informed consent and confidentiality has been strictly maintained. Transcripts and reports were pseudonymised to protect participant's identity and data will be stored securely. The research ethical standards were met through ethical approval by a relevant research ethics committee.

3.2. Rationale for Focus Groups

Focus group discussion is a dynamic and collaborative medium of discursive interaction in which participants share their experiences and interact with others' view points. This method is especially well suited to determining how students perceive and react to fluoride and the educational materials delivered by AIGC. Focus groups spark rich qualitative data for qualitative research that reveals the complexities of the participants' experiences that are essential for understanding your research questions [14, 15]. This approach takes account of the data, allowing for the best results to be obtained as the data collected is both in depth and is reflective of the different experiences of college students from areas with highest fluoride endemicity.

3.3. Explanation of Demographic Characteristics

To represent gender, age, academic disciplines and prior knowledge of the impacts of fluoride, focus group participants have been selected with a range of fluoride endemic regions of china such as Jiangxi Province. Here's a breakdown of the demographic characteristics and their significance to the study:

3.4. Gender Distribution

The participants were male (50%) and female (50%). By avoiding extensive reliance on gendered representation, this balance empowers gendered perspectives of how fluoride exposure affects mental health as well as engagement with AI generated content (AIGC) educational materials. Gender can affect how people perceive their health for some and impact on the ability to access resources, so this distribution needs to allow any gender specific themes to be picked out on analysis if necessary.

3.5. Age Group

A large majority of participants were between 18 and 26 years of age (average age = 24.3 years), with most being in the 21-23 year range (40%) followed closely by equal numbers in the 18-20 (30%) and 24-26 (30%) year age brackets. This range is commonly found in college aged individuals, ranging from 21 – 24 years, individuals who may be particularly susceptible to mental health stressors for various reasons such as academic pressures and transitional phases of life. This age diversity allows us to determine if perception of

fluoride exposure and mental health are different within the college age demographic.

3.6. Academic Discipline

They were participants from degrees in Science and Technology (35%), Humanities (25%), Business (15%) and Social Sciences (25%). It is crucial to both capture various perspectives, as students in different fields may have varying levels of exposure to environmental health information and different approaches to making sense of and responding to health related information, but also to ensure that both control for student differences and also securely distribute the burden of work across the population. For example you might find science students more knowledgeable of scientific concepts or Humanities students who will focus on socio cultural interpretations of health.

3.7. Region of Residence

All participants lived in areas of high fluoride exposure. Due to this target population, the study can not only analyze the perceptions and health effects related to fluoride exposure among those residing in areas with high levels of fluoride, but also directly contribute to informing public health practices in the same areas.

3.8. Prior Knowledge of Fluoride Impacts

Eighty percent of participants were reported to have had no prior knowledge of the mental health impact of fluoride exposure, which represents a large information gap. Yet just 20 per cent indicated prior awareness. It is especially important to recognize that the body of prior knowledge is limited in these cases because the intervention will have a more observable impact on those unfamiliar with the topic. The detailed demographic description presented in table 1.

Table 1: Demographics of Focus Group Participants

Demographic Table of Focus Group Participants			
Demographic Variable	**Category**	**Number of Participants**	**Percentage (%)**
Gender	Male	10	50%
	Female	10	50%
Age Group	18-20 years	6	30%
	21-23 years	8	40%
	24-26 years	6	30%
Academic Discipline	Science and Technology	7	35%
	Humanities	5	25%
	Business	3	15%
	Social Sciences	5	25%
Region of Residence	Fluoride-Endemic Area	20	100%
Prior Knowledge of Fluoride Impacts	Yes	4	20%
	No	16	80%

4. RESULTS

In this study we analyze the mental health effects of using Generative AI Content and the impact on public health perceptions. The focus group discussions are summarized in a manner which is visualized in Figure 1. The themes from each bar to the left indicate their areas of discussion and the length of each bar represents the percentage of number of participants who mentioned each theme. Here's an interpretation of each theme based on the chart:

4.1. Interpretation of Results

1. **Knowledge Gaps Identified (90%)**
   A large majority of participants were initially unaware of mental health risks associated with fluoride exposure, and this theme has the highest percentage of mentions (90%). This implies a large gap in fluoride knowledge among college students in fluoride endemic regions, and the implication is for educational initiatives for the respective

improvement of knowledge. Also, the high level of mentions indicates that participants were highly open to new information, as became evident when they realised they didn't know what was going on.

2. **Perceived Mental Health Impacts (85%)**

With regard to the perceived mental health impacts of 85 percent of participants they mentioned anxiety, cognitive difficulties, and emotional instability – close to the knowledge gap theme. This high percentage indicates these are not just students who are experiencing, but it's students who also believe are dealing with some form of mental health symptoms due to they think fluoride exposure. This point emphasizes the desperate need for more research and awareness work concerning the health threatened by the effects of fluoride, as the participants readily shared their own experiences with or concerns about fluoride-related mental health impacts.

3. **Effectiveness of AIGC Materials (75%)**

The AIGC materials were deemed effective by 75 percent of participants.. The reaction to the AI generated content appears to be extremely positive, with reporting that it helped their understanding of fluoride's potential health effects. As valuable educational tools the AIGC materials were perceived as simplified explanations with engaging visuals. The results of this level of engagement indicate that AIGC could be a promising approach to future health awareness campaigns aimed at youth.

4. **Engagement and Accessibility (65%)**

The theme 'engagement,' mentioned by 65% of the participants and reflecting both 'high' engagement derived from AIGC materials as well as 'low' accessibility. The students have found the materials engaging and found them helpful in understanding complex health topics, but struggled in accessing such resources, especially in low resource settings.

This means the potential is there that AIGC has much to offer, but accessibility issues must also be addressed so that all students can learn with these educational materials, regardless of technological resources.

5. **Barriers to Implementation (50%)**

Forty five percent of participants reported barriers to implementing fluoride related health initiatives. Cultural stigma around the topic of mental health, the lack of institutional support and even the possibility of people getting resistive when thinking about mental health and environmental health matters are barriers within these exchanges to talk about environmental health at a managerial level.

On the side of relatively lower percentage of the barriers that are acknowledged compared to other themes, this indicates that the participants might not really consider them as immovable obstacles. However, this theme points towards the need for strategies to deal with cultural as well as institutional challenges at the time of implementation of the public health initiatives.

Results of the chart showed that there were significantly few college students that are generally uninformed on fluoride's impact to mental health, but are willing to learn and can easily learn through AIGC as an educational medium. The Knowledge Gaps Identified and Perceived Mental Health Impacts are discussed with a high frequency suggesting a call for awareness initiatives.

The Integrity of the AIGC Materials reinforces the viability of employing AI produced content for health education but additional work is required to expand these resources to a widespread audience. Finally, Barriers to Implementation reminds stakeholders of those cultural and logistical challenges that are required to overcome in order for any awareness campaign to be successful.

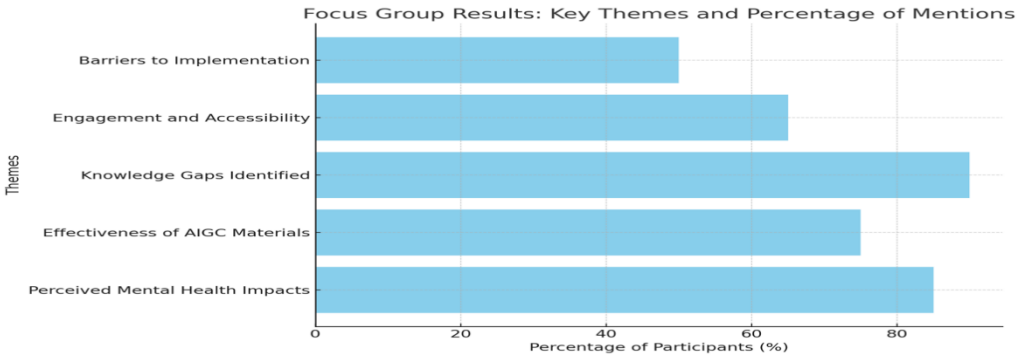

Figure 1: Thematic analysis of the focus group

4.2. Distribution of Themes Based on Participant Mentions

Figure 2 shows the distribution of the key themes discussed in the focus group according to the percentage of the participant mentions for each theme. Knowledge Gaps Identified is by far the largest portion of the chart, taking up 24.7% of the mentions, showing that almost a quarter of mentions related to a prior lack of knowledge about the mental health impacts of fluoride. However, there is this significant information gap which points to the need of educational initiatives aimed at filling in this gap. Perceived Mental Health Impacts is the second largest at 23.3% of mentions. The theme here is about mental health and how participants worry about anxiety and cognitive issues that they associate with fluoride exposure in areas that get high fluoride exposure and it forces us to think about mental health, if you have high fluoride exposure.

AIGC Materials at 20.5 % of the chart displays a positive participant feedback on the role of AI generated content (AIGC) in simplifying complex information and enhancing understanding of fluoride's health effects. This fairly large piece suggests that AIGC materials are high in perceived effectiveness and perceived engagement as health education tools for college students. Engagement and Accessibility is another major theme made up of 17.8 percent of mentions. Participants liked the interactive nature of AIGC materials, but raised accessibility issues — acknowledging that while AIGC has value, access might be enhanced for students in low-resource settings.

Finally, the least developed of all is the theme of Barriers to Implementing which accounts for 13.7% and illustrates the existence of many barriers to dealing with fluoride health issues, for example cultural stigma and lack of institutional support. Although this theme is not mentioned as frequently, it is equally important when it comes to effective addressing of fluoride related health concerns, because of the societal and institutional changes that will be required more broadly in order to achieve this objective.

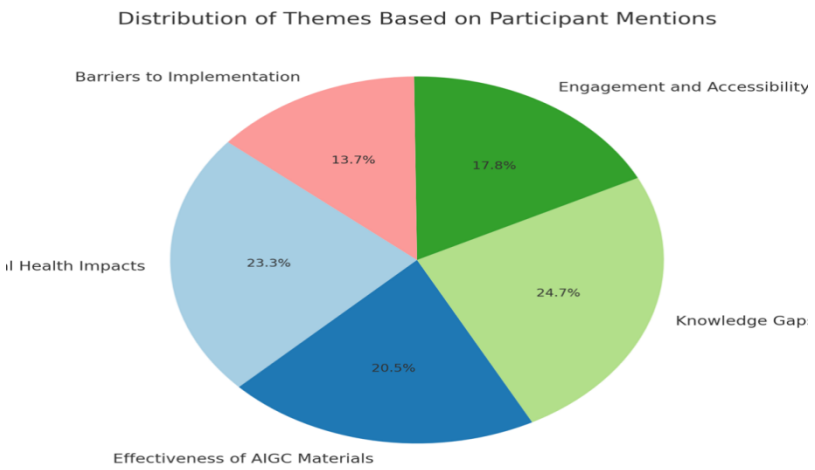

Figure 2: Distribution of thematic analysis

The Results Table 2, which summarizes and presents the key themes in the discussions with the dimensions, brings out insights of the participants and the proportion of participants to each dimension. These findings further suggest salient aspects of how participants are aware of the mental health effects of fluoride, of the perception of the AI generated content (AIGC) in teaching, and handling of the instructional effort on this topic. Perceived Mental Health Impacts was the most mentioned theme, that 85% of the participants expressed they are aware of mental health problems related to fluoride exposure which encompass feeling of anxiety, cognitive problems etc. Since this is such a high percentage, there is a lot of concern over what fluoride is doing to mental health, especially among college students living in areas with fluoride. It underscores the necessity for these regions to become aware and receive mental health support due to fluoride exposure.

Effectiveness of AIGC Materials was mentioned as the second most prevalent theme by 75% of participants. Great about these materials was their effort in making the complex scientific information easier to understand. The positive reception of AIGC implies that AIGC could prove useful in future health awareness campaigns aimed at young adults as well as presenting an opportunity to enhance health literacy. An overwhelming 90% of participants came into the theme Knowledge Gaps Identified, where most participants did not even know that fluoride could have an impact on their mental health. This finding also revealed that there was a huge misunderstanding and needed to be looked at correcting it, it was clear that traditional educational methods did not adequately address the concerns that youth face. The popular notion of drinking fluoride is significant in references in literature yet underscored by the high number of mentions, indicating the urgency of teaching targeted educational interventions to close this knowledge gap and understanding of fluoride influenced health issues. Participants said 65 percent of them talked about the theme Engagement and Accessibility. Participants liked the interactive nature of AIGC materials but noted challenges of accessibility, particularly in low resource settings. This is useful in that it suggests that the content is engaging despite the fact that accessibility is still a problem for some students, and that adaptive models would be necessary to reach those without other sources of reliable digital content.

Additionally, 50% of respondents believed that Barriers to Implementation would represent both the cultural and institutional barriers to addressing fluoride related public health issues including mental health stigma and a lack of institutional support. Fewer participants brought up this theme, but it precipitates the major external factors which might impede the utility of educational and health interventions. These barriers, however, need to be overcome through wider systemic changes, including facilitating greater support for mental health discourse and securing backing from institutions for fluoride related health awareness programs. The Focus Group Results shown in Table 2

overall gives a clear sense of participants' perceptions and experiences. Knowledge Gaps Identified and Perceived Mental Health Impacts, however, show that there is a huge opportunity for awareness initiatives around fluoride exposure's mental health impact. Effectiveness of AIGC Materials is positively received, and may be a key tool to bridge knowledge gaps these materials present with AI generated content. Despite this, the themes of Enagement and Accessibility and Barriers to Implementation introduce logistical and cultural difficulties that must be reconciled to take full advantage of these interventions. These findings reinforce the importance of delivering culturally sensitive, accessible, engaging educational content in addressing public health problems in fluoride endemics regions.

Table 2 : Focus Group Results

Theme	Key Insights	Percentage of Participants Mentioning Theme (%)
Perceived Mental Health Impacts	Participants reported anxiety, cognitive difficulties, and emotional instability linked to fluoride exposure.	85%
Effectiveness of AIGC Materials	AIGC materials helped participants better understand fluoride's effects through visuals and simplified explanations.	75%
Knowledge Gaps Identified	Participants were unaware of fluoride's potential health impacts before the session, highlighting significant gaps.	90%
Engagement and Accessibility	Students appreciated the engaging nature of AIGC but noted challenges with accessibility in low-resource settings.	65%
Barriers to Implementation	Cultural stigma and lack of institutional support were cited as barriers to addressing fluoride-related issues.	50%

4.3. Focus Group Themes and Participant Mentions

Figure 3 shows a heatmap that depicts the percentage of participants mentioning each primary theme brought up in the focus groups—and increasingly darker colors represent higher intensity responses. In darker shades higher percentages, and in lighter shades lower percentages. The darkest shading depicts the 90% intensity of the theme Knowledge Gaps Identified. This implies that college students didn't know that fluoride exposure can have detrimental impacts on mental health in most cases leading to a big knowledge gap area at this level. The large presence of this theme in the heatmap shows this absence of awareness is a big issue that should be targeted with specific educational campaigns. This second most prominent theme, as judged by the presence of 85% of participants discussing perceived mental health impacts associated with fluoride exposure, is also cast in a dark shade. The high fingerprinting does indicate that mental health problems like anxiety and cognitive problems are very relevant in areas with high fluoride exposure, and it is an important area to dig further in.

Effectiveness of AIGC Materials is illustrated in moderately dark tone with 75 percent of participants recognizing the value of AI generated content in widening their understanding of fluoride's health impact. Given this intensity, this colour must represent AIGC perceived value in educating young adults. Engagement and Accessibility is a lighter shade than this as 65% of participants discussed the interactive and engaging properties of AIGC, but highlighted challenges of accessibility, especially in low resource environments. When we said the learning experience of AIGC is of moderate intensity this implies AIGC has a better chance at being of use but accessibility needs improving to maximize its effectiveness.

Barriers to Implementation, the final chapter, appears in lightest shade—50 percent of participants mention barriers like cultural stigma and lack of institutional support. This is the least mentioned theme, however it points to important issues which need to be addressed to enhance public health interventions. The lower emphasis reflected in the lighter shade makes it a little easier to see, but it still hints at some serious issues.

Finally, the themes are displayed in a way that generates heat, or value, as an indication of how

important each participant may find specific themes. This is shown in Figure 3. The most prevalent themes identify Knowledge Gaps Identified and Perceived Mental Health Impacts as well as call for more enhanced awareness and education regarding fluoride exposure. A second major theme is the Effectiveness of AIGC Materials, demonstrating that AI generated content can be valuable in health education. Engagement and Accessibility and Barriers to Implementation have 2 primary and 2 secondary colors, meaning they are important, but discussed less often. The priority of this focus group can be seen in this heatmap: it's a clear visual summary of the focus group's priorities and identifies valuable insights for future public health education and intervention strategies.

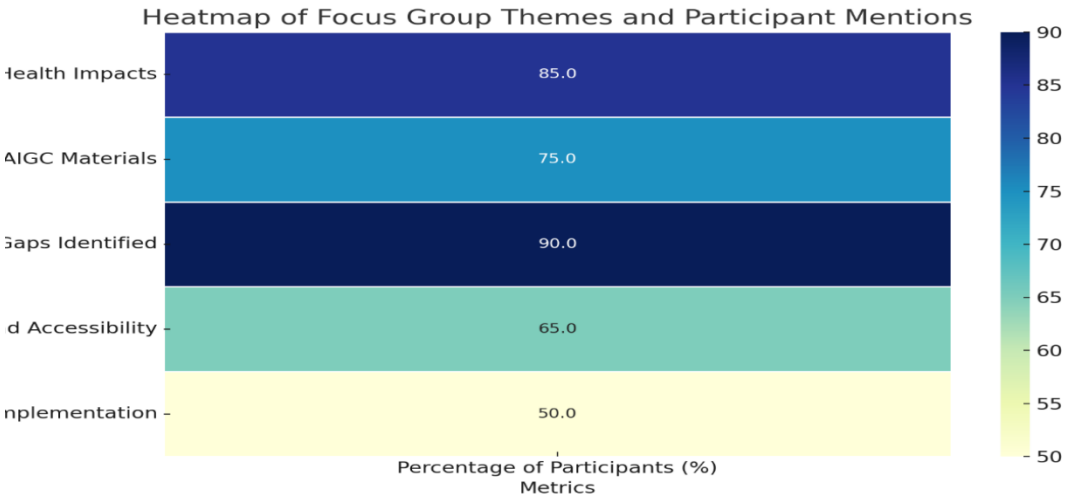

Figure 3: Heat map of focus group discussion

5. DISCUSSION BASED ON RESEARCH QUESTIONS

The results of this study are provided to the perception of mental health impacts on fluoride exposure among college students and the result of AI generated content (AIGC) intervention for education. Examination of these issues in the context of fluoride endemic regions in China is the first study to contribute to a scant body of literature linking environmental neurotoxins to mental health in young adults. In the following discussion, research questions are further expanded on through back ground information from existing studies.

1. ***Research Question 1:*** **What are the perceived mental health impacts of fluoride exposure among college students in fluoride-endemic regions of China?**

Focus group findings reveal broad belief in a link between fluoride and mental health, and 85 percent of participants mentioned things like anxiety, cognitive problems and emotional imbalances. These fit closely previous studies of the neurotoxic effects of fluoride. [16, 17] also found that chronic exposure to fluoride, even in high fluorine areas can result in cognitive deficit and decreased IQ of the children. These studies, which looked mostly at children, imply that the neurotoxic effects of fluoride could also affect cognitive function among young adults, including college types under consequent stress related to school work as well as environmental exposure.

Also, research in animal models has shown by Shimabukuro [18] that fluoride exposure results in changes of neurotransmitter levels that may be responsible for anxiety and mood dysregulation in humans. Although animal studies do not immediately translate into human results, they support the hypothesis that fluoride can interfere with neurological processes, and thereby cause effects to the mood and potentially cognitive impairment, as reported by participants in this study. Specifically, College students in areas with high fluoride exposure report mental health problems, which are unique to the exposed population, suggesting that such environmental factors might aggravate as well as contribute to the presence

of mental health stressors commonly identified among young adults.

In countries like Pakistan, where certain regions face endemic fluoride contamination in drinking water, the cumulative effects of environmental fluoride on mental health may be further compounded by academic and social pressures commonly associated with college life. Research on student mental health has demonstrated that environmental factors like pollution cause higher levels of anxiety and depression [19]. The findings of this study extend these by suggesting that fluoride is a potential environmental risk factor. Our focus group results suggest that there is a high prevalence of perceived mental health impacts in young people in their twenties for which further research needs to be carried out into the biological pathways through which fluoride exposure could contribute to psychological and cognitive symptoms, particularly in young people whose neurodevelopment is ongoing.

In addition, participants' perception of how fluoride affects their mental well being highlights the importance of provision of targeted mental health resources in fluoride regions. But many described trouble concentrating, more stress and emotional instability they attributed to long exposure to fluoride. According to these findings, students in these areas may benefit from colleges in high or moderate fluoride areas to incorporate environmental health awareness into their systems of support for mental health. As future research, it could focus on interventions tailored to address environmental contributors to mental health among college students, like filtered drinking water programs and environmental health literacy initiatives.

Research Question 2: How effective are AI-generated content (AIGC) educational materials in increasing awareness and promoting mental health among college students?

Results showed that AIGC materials were extremely good at increasing awareness and understanding of fluoride's potential health effects, as 75% of participants reported that the AIGC helped greatly in increasing their comprehension. AIGC's 'visually engaging' nature, from infographics, to animations to simplified explanations, was particularly noted for providing quick access to esoteric scientific information to students. This study is consistent with previous findings of the effectiveness of digital and AI driven content in health education. AI generated materials, ones that take complex information and adapt it visually to compelling formats, worked especially well for younger audiences used to digital media, as Onyejelem and Aondover [20] observed.

Since previous studies have demonstrated that health related AIGC can help achieve a greater level of understanding and retention of information [21]. Since it's been so successful in helping engage younger populations, AI driven educational tools for nutrition and fitness have simplified scientific information and offered interactive experiences. The findings in this study are extended by exploring the value of AIGC to environmental health education as a means of increasing awareness of fluoride exposure, a difficult, and often overlooked, health issue. AIGC's positive reception from participants showcases the capacity of this technology to close important knowledge gaps for under informed populations.

The most frequently mentioned theme of Knowledge Gaps Identified was that of fluoride's mental health effects, as 90% reported lacking significant or little knowledge about it at the start. This agrees with previous research suggesting that young adults are generally not well informed about the environmental component of their health[22]. This gap was filled by the AIGC intervention that provided clear, visually engaging content that resonated with participants. If AIGC is applied above and beyond what AIGC has been developed for – meaning public health issues – this emphasis on awareness post intervention highlights its potential as a scalable accessible educational tool for public health issues, specifically ones where conventional education methods fail.

Despite that, some of the participants voiced accessibility challenges, particularly in low resource settings where digital access may not be reliable. This finding emphasises a significant limitation of the AIGC, given that the digital infrastructure is dependent on and may not be available to all students in fluoride endemic areas. Like studies on digital education, other studies of digital education have echoed similar fears of technological gaps in access, as digital tools amplify educational disparities unless adapted to different resource levels. To overcome this limitation, the future health campaigns may explore such hybrid models where AIGC is combined with traditional methods like printed materials or in person workshops and can reach more people.

6. IMPLICATIONS OF FINDINGS

The findings for the research questions emphasize the critical need for targeted health interventions and education in fluoride endemic regions. Although only a small percentage of participants reported actual fluoride-related neurotoxicity, a high percentage reported perceived mental health impact, which should be a focus of public health policy for young adults living in these areas. So educational institutions and public health agencies can be more active about promoting awareness of their exposure to fluoride and promoting mental health resources for college students.

Additionally, the ability of AIGC materials to fill in knowledge gaps indicates that AI developed educational tools can form the cornerstone of awareness campaigns in health. This simplified and engaging content resonates with youth and has potential to demystify complex health issues that don't attract the attention of adults. Nevertheless, just as a few participants highlighted some of the accessibility challenges associated with AIGC, there will be a need to address those challenges in order to broaden the benefits of AIGC. Therefore, they could help policymakers and educational institutions to consider investment in infrastructure supporting digital health education in regions of high environmental health risks.

7. FUTURE DIRECTIONS

Several avenues for future research are opened by the study's findings. Longitudinal studies could be conducted of long term mental health impact due to exposure to fluoride among college students using both subjective reports, but also objective measures. Further research may also look into the particular biological mechanisms by which fluoride may lead to neurotoxicity as the associations seen between the level of environmental fluoride and cognitive symptoms found in this study, and in other studies. Finally, if AIGC were to be applied to other environmental health topics, this could further validate AIGC as the method of choice for educating the public about a number of under addressed areas in environmental health.

8. CONCLUSION

Findings are discussed in terms of research questions, emphasizing how AIGC has potential to be a transformative educational tool and highlighting how college students living in fluoride-endemic regions are vulnerable to psychological impacts. AIGC was effective in raising large awareness about the risks in mental health related to fluoride exposure, yet has yet more work to be done with regards to accessibility barriers and to slipping these tools into broader public health strategies. This thesis thus offers important contributions to the environmental health and digital education literature by identifying and illustrating why innovative and inclusive methods of public health education are critical in municipalities that encounter environmental health challenges.

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