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Interconnected Networks in Fluoride Awareness and Risk Communication: A Strong Product Graph Model for Public Health Strategy

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ABSTRACT

Background: The dental health benefits of fluoride have been known for a long time because the compound stops cavity development and helps teeth rebuild minerals naturally. The limited studies investigating public health fluoride awareness programs fail to show their impact on various population groups. Research investigates fluoride safety practice adoption among public health networks by studying both general population behavior and athletic groups and their knowledge of fluoride benefits and risks.

Objectives: The main goal of this research investigates how fluoride awareness programs affect public health strategies alongside the adoption of fluoride safety measures. This research examines the way that assessment of risk acts as a mediator between health authority relationships and it investigates the moderating power of community trust through a Strong Product Graph Model network analysis of interconnections.

Methods: Researchers utilized a mixed approach to gather data by conducting surveys alongside interviews as parts of their methodological design. The researcher obtained responses from 254 survey participants consisting of Chinese athletes and general population members. The research utilized Path analysis performed with SMART-PLS to evaluate connections between fluoride awareness programs and perceived risk as well as community trust toward health authorities and fluoride safety measures and public health outcomes effectiveness.

Results: Research findings showed fluoride-based education programs produced substantial improvements in public practice of fluoride safety and achievement of Public Health goals. The variables of perceived risk acted as a mediator among different relationships while health authority trust levels weakened the influence of fluoride awareness education on perceived risk outcomes. Athletes revealed divergent results from the standard population through the research which indicated better fluoride safety practice adoption together with better public health outcomes for this specific group.

Conclusion: The study confirms that fluoride education programs are vital for developing safe fluoride practices which lead to better public health results. The research adds fresh knowledge about improving fluoride education effectiveness through addressing perceived risk levels and community trust rates. Further research needs to document the long-term effects of current fluoride initiatives together with methods to appropriately communicate fluoride messages among distinct population groups.

Keywords: Fluoride Awareness, Public Health Strategies, Perceived Risk, Community Trust, Health Communication, HBM Model

INTRODUCTION

People across the world recognize fluoride because it plays an essential part in dental health through dental caries prevention and enamel reinforcement. Due to its contributions to bone strength fluoride plays a vital role in preventing skeletal conditions and maintains overall human health benefits. Large amounts of fluoride intake produce dental fluorosis as well as skeletal fluorosis in the human body. The combination of these conditions creates extensive obstacles mainly affecting residents living in water sources with high fluoride content and users of excessive fluoride-containing dietary items and oral hygiene products [1]. Success in resolving fluoride-related challenges needs targeted public health strategies which promote both fluoride advantages and risk reduction by promoting broad-based awareness and clear communication.

Public health fluoride safety initiatives depend on three main factors which include how well citizens understand the advantages versus disadvantages of fluoride and the extent to which people trust public health organizations. The successful translation of fluoride information requires complete understanding because it shapes how people view fluoride usage and their behaviors regarding it [2, 3]. Communities suffering from high fluoride exposure develop health-related misconceptions or practice inadequacies because unreliable or insufficient information sharing subsequently increases both risks alongside inequalities [4]. The study examines the role which fluoride awareness networks combined with community trust networks and risk perception structures play in influencing public reactions to fluoride safety programs and healthy communication practices [5] .

The Strong Product Graph Model will serve as the analytical tool to examine the interconnected patterns of fluoride awareness programs and public fluoride risks alongside public trust in authorities and fluoride safety practice adoption. An investigative analysis of factor interactions leading to public health impacts becomes possible through the application of this model. This study transforms the Health Belief Model into a theoretical framework to monitor how people process information regarding fluoride safety while examining both rational and affective factors influencing change in behavior [6, 7]. Understanding fluoride use and safety behaviors in different socio-cultural settings requires using the HBM framework along with its core elements of perceived severity, susceptibility, benefits, and barriers to assessment. Fluoride awareness combined with risk communication tools serve as main elements to enhance public involvement and shift individual behavior patterns [8].

The research maintains crucial value for the general population because it addresses worldwide fluoride exposure differences and requires immediate public health communications that minimize risks but still provide access to fluorides in a safe manner. The findings from this study will generate practical solutions for establishing public health approaches that specifically meet distinct population requirements in public trust advancement and risk evaluation together with behavior transformation. The current study used mix method of searching detailed literature and using sentiment analysis performing word-cloud, graph model and quantitative study using survey design. The study will provide indispensable information to policymakers together with public health officials and organizations which work on enhancing fluoride safety measures and health communication effectiveness within public health.

LITERATURE REVIEW

Dental health benefits significantly from fluoride intake which medical professionals endorse to stop tooth decay development. Public health experts need to understand the numerous complexities surrounding fluoride use especially as it is employed in different nations worldwide. Consumption of large fluoride amounts produces health issues but small regulated amounts provide dental care benefits. Extended fluoride intake leads to the formation of dental fluorosis together with skeletal fluorosis as its major health outcomes. Health experts in the public health field have continued to debate these risks for many years [9]. The elevated fluoride content in drinking water of Pakistan and China affects population groups most severely because these nations naturally possess high fluoride concentrations. This exposure danger intensifies prominently in distant rural zones because proper drinking water accessibility is restricted [10]. The analysis investigates fluoride exposure physics and implementation of fluoride safety routines across Pakistan and China while analyzing the delivery methods of fluoride risk information to both country populations.

Fluoride Awareness and Risk Communication in Pakistan and China

Awareness programs about fluoride have acquired critical importance in Pakistan and China particularly in their rural and undeveloped areas because fluoride damages the water supply. Fluoride contamination affecting drinking water exists mostly in Pakistani provinces Sindh and Punjab because high fluoride content has led to dental fluorosis cases increasing. Research demonstrates that Pakistani officials launched grassroots-based awareness programs to teach residents about both fluoride water safety and harm from excessive fluoride consumption [11]. Public initiatives face difficulties because people lack knowledge about fluoride together with its possible dangers. Academic research proves that public knowledge about fluoride advantages and disadvantages directly determines the results of awareness programs [12]. The public health initiatives in Pakistan need to combat wrong information about fluoride toxicity through education that addresses cultural misconceptions and healthcare authority distrust [13].The Chinese public faces additional challenges because the massive citizen population coexists with different fluoride concentrations found in various parts of the country [14]. Rural areas possess elevated fluoride content in their ground sources which exceeds maximum safety standards causing alarm over skeletal fluorosis risks to residents. Chinese officials have launched multiple health education campaigns which target mostly rural areas because that is where most cases of fluoride-affected diseases occur [15]. The Chinese public health authorities have launched educational initiatives about fluoride risks and benefits yet local health agency mistrust has limited the effectiveness of these educational drives according to Chen, Xia [16]. Research conducted in China demonstrates that residents living in fluorosis-endemic zones view fluoride as dangerous although medical data indicates safe utilization of fluoride for dental health purposes [17]. To succeed in fluoride safety education the communication strategies must combine classroom education for proper fluoride knowledge with building stronger relationships between community members and health authorities.

People from Pakistan and China differ in their viewpoint regarding fluoride exposure risks-the way people in Pakistan and China view fluoride risk determines their responses to fluoride risk communication efforts. Whether fluoride appears safe or dangerous to people depends on how much they encounter the substance along with their familiarity with its characteristics. The risk perception of fluoride exposure in both nations depends on how people experience fluoride substances together with the cultural customs that govern fluoride consumption [18]. Parkistani society shows increased sensitiveness toward fluoride-related dangers because people frequently develop dental fluorosis from drinking excessive fluorine in their water. People living in rural communities which lack sufficient fluoride-free water regularly consider fluoride as dangerous although it provides dental advantages at recommended amounts. Difficulty perceiving fluoride exposure risks negatively affects how people interpret their fluoride consumption leading them to reject fluoride programs mainly because of ineffective communication about fluoride safety.

China experiences the impact of fluoride exposure because this substance affects large geographical areas throughout the country. Fluoride generates widespread concern as a dangerous substance among people dwelling in Shanxi and Guizhou provinces which encounter high fluoride exposure. High awareness exists about severe skeletal fluorosis as a result of excessive fluoride ingestion because this condition has become the primary negative perception associated with fluoride consumption in China [19].

Community Trust in Health Authorities

The trust levels which communities have in their health authorities determine how people from Pakistan and China understand fluoride health messages. Local health authorities and governmental organizations determine the success rate of fluoride risk communication delivery to the public. People in Pakistan do not trust their health systems because the country experienced years of ineffective public health measures [20].Local health authorities maintain distant relationships with numerous rural Pakistani populations who doubt their capacity to offer truthful information. Public mistrust worsens the difficulties of spreading fluorides-related knowledge and information. The challenge for Pakistani public health campaigns lies in information mistrust since citizens will only follow directions from health agencies if they perceive the information as trustworthy.

A number of historical political and social factors in China have resulted in different levels of trust between citizens and their health authorities. Urban populations have increased confidence in governmental health bodies because the government has established extensive public health programs which address fluoridation practices. The rural areas exposed to high fluoride levels maintain substantial distrust toward local health authorities because of previous inadequate fluoride risk management [21]. Caused by mistrust it becomes challenging to explain fluoride advantages and risks to the public effectively. The establishment of effective communication strategies needs to build trust with the public through open communication approaches that engage local communities.

Adoption of Fluoride Safety Practices

Regional fluoride exposure levels and the awareness level of the public and their trust in government agencies together with their perceived risks determine the extent to which Pakistan and China adopt fluoride safety practices. The limited implementation of fluoride safety practices in Pakistan persists mainly because rural areas lack both dental care facilities and access to fluoridated consumer products alongside inadequate fluoride literacy advancement by the government.

The unwillingness of public communities to practice fluoride safety comes from their mistrust of health authorities and their cultural viewpoints regarding fluoride risk. Many areas show limited adoption of standard fluoride safety measures including fluoridated water consumptions and fluoride toothpaste use since residents practice traditional dental care methods [22]

The practice of fluoride safety has gained increased recognition in Chinese urban areas because residents in these areas can get easy access to fluoridated water and dental products containing fluoride. Public health education programs together with fluoride exposure risks prevent numerous rural populations from adopting these safety practices according to [23]. The local residents' skepticism toward health authorities and their perceptions of risk need proper attention to enhance the practice of fluoride safety in these areas.

Public Health Strategy Effectiveness

Public health strategies succeed at improving fluoride safety by creating successful fluoride awareness initiatives and risk communication efforts and fluoride safety practice implementation. The outcomes from public health campaigns in both Pakistan and China have shown inconsistent results. Public health approaches in areas with excessive fluoride levels succeeded in teaching the population how dangerous fluoride exposure becomes when it exceeds safe limits [24].

Public health strategies have not sufficiently ensured safer practice adoption because they failed to resolve baseless distrust combined with the circulation of incorrect information. Research indicates that health programs must focus on education and cultural obstacles which stand in the way of fluoride safety protocols adoption success. The detailed key findings of literature review is presented in table 1.

A word cloud demonstrates important connections among fluoride knowledge spread and effects on inhabitants of rural areas. The visualization’s dominant

Table 1: Key findings from Literatures

Study	Key Findings	Variables	Future Insights
[25]	Grassroots-based fluoride awareness programs in Pakistan have proven critical in educating rural communities. However, misconceptions about fluoride toxicity persist, and overcoming public mistrust of health authorities is a significant barrier.	**Dependent Variables**: Public knowledge of fluoride, adoption of fluoride safety practices, public trust in health authorities. **Independent Variables**: Type of awareness program, exposure to fluoride toxicity information, level of trust in health authorities.	Future studies should explore targeted interventions focusing on trust-building and culturally tailored communication strategies for rural populations.
[26]	In China, fluoride awareness campaigns target rural areas where high fluoride exposure risks are more common. Skepticism toward fluoride use persists, especially in areas with prevalent skeletal fluorosis.	**Dependent Variables**: Public perception of fluoride, adoption of safety measures, fluorosis incidence. **Independent Variables**: Type of health education programs, fluoride exposure levels, region of residence (rural vs. urban).	Further research can focus on improving the effectiveness of health campaigns by incorporating local community involvement and reducing misconceptions through localized educational materials.
[27]	Despite government-led fluoride education campaigns, rural residents exposed to high fluoride levels remain skeptical of fluoride benefits. Trust in health authorities is a key barrier.	**Dependent Variables**: Trust in health authorities, public adoption of fluoride guidelines, fluoride-related health outcomes. **Independent Variables**: Government health interventions, local fluoride levels, public trust in health authorities.	Investigate the role of community-led health initiatives in increasing trust and the effectiveness of decentralized health communication models in fluoride education.
[28])	Public health programs in Pakistan have emphasized fluoride toxicity education. Success is closely tied to addressing cultural perceptions and misconceptions regarding fluoride in rural communities.	**Dependent Variables**: Fluoride safety practices adoption, public health knowledge. **Independent Variables**: Public health messaging, cultural beliefs, awareness of fluoride toxicity risks.	The study suggests further research on understanding cultural differences in the acceptance of fluoride programs and tailoring communication strategies to rural communities.
[29]	The study revealed that the limited implementation of fluoride safety practices in rural Pakistan is due to a lack of dental infrastructure and reluctance to accept fluoride interventions due to distrust in government health messages.	**Dependent Variables**: Fluoride safety practices adoption, public trust, prevalence of dental fluorosis. **Independent Variables**: Health infrastructure, fluoride education programs, public trust in government.	Future studies should assess the effectiveness of integrating fluoride safety practices into the local health infrastructure and exploring alternative delivery methods in rural areas with minimal dental services.

Figure 1 : Word-cloud of the literature.

terms include "fluoride," "safety," "trust," "communication," and "health" which highlight fluoride safety practices together with their impact on public perceptions. Words "rural" "public" "awareness" and "education" appear larger in the word cloud to show the research interest in these domains that concerns under served communities receiving fluoride exposure. The importance of health institution trust and communication strategies for enhancing fluoride safety practices stands out through words such as "trust," "health authorities" and "program." The cloud demonstrates the necessity of dealing with misunderstandings and regional cultural beliefs about fluoride exposure and requires specific intervention strategies to achieve awareness enhancement across different populations through local community involvement. The figure 1 presented word cloud which used for the choosing the variables to perform the qualitative study.

Key Variables and Future Insights

The evaluation focuses on six outcome variables which cover the public understanding of fluoride alongside their perceptions about the substance as well as their fluorides safety habits and dental health effects of fluoride along with their trust in health institutions.

Independent Variables: These encompass the type of fluoride awareness program (grassroots or institutional), regional fluoride levels, exposure to fluoride information, cultural beliefs and misconceptions, and the effectiveness of communication strategies.

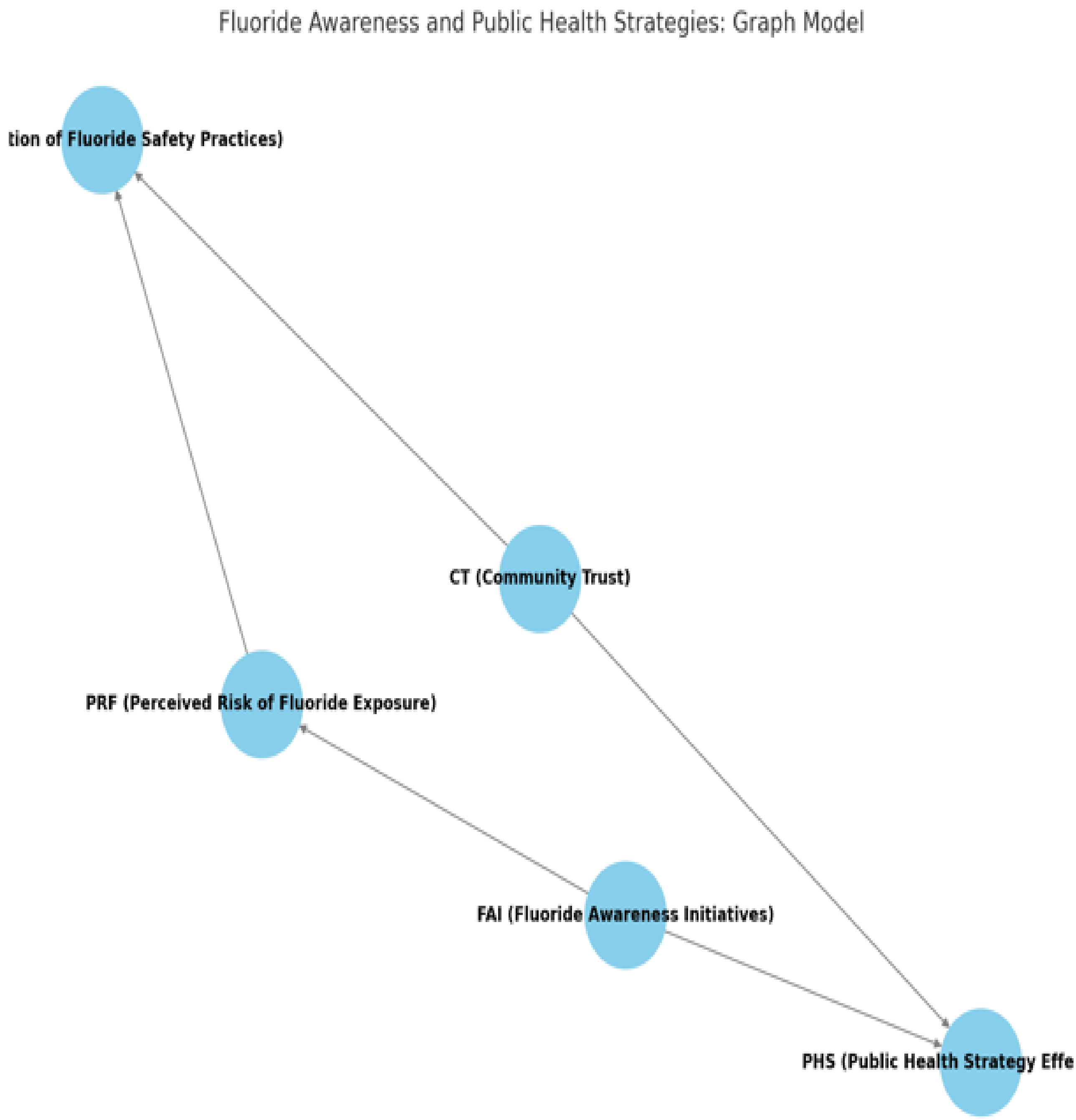


Figure 2: Tree map of the graph model

Future Insights for Current Study:

Research implications demonstrate that scientists must explore additional relationships between public health communication tactics and health authority trust levels. Research must clarify the methods used to build trust because they directly affect fluoride safety practices and awareness improvements in rural and under served areas.Future investigations need to evaluate which local initiatives led by communities prove most effective to educate people about fluoride's associated risks and benefits when handling cultural and regional-specific fluoride exposure concerns.

Additional studies need to investigate specially designed approaches for improving acceptance rates of fluoride safety measures because rural and under served areas face higher fluoride-related health issues.Further investigations will support the development of enhanced fluoride risk communication methods through consideration of variables combined with the findings gathered from this research especially for countries such as Pakistan and China.

The Graph Model in this research establishes a systematic visualization of essential components that link variables regarding fluoride awareness to public health actions. The Fluoride Awareness Initiatives (FAI) node stands as the central component because it works as the primary element that affects how people view fluoride risks. The PRF concerns of people increase after awareness programs so they start practicing AFS. The model demonstrates the essential function which Community Trust (CT) plays in controlling the relationship dynamics between components. Both the acceptance of protective measures and successful outcomes of public health initiatives receive increased benefits when people trust their health authorities. Public health strategy success improves because the FAI node establishes direct connections to PHS. The tree diagram reveals both the variable sequence of fluoride awareness effects which steer health behavior modification while emphasizing trust as a vital influence on these changes.

The research adopts the Graph Model to show the connections which drive influences among the study variables.

The research utilizes the Graph Model to display its visual network that demonstrates the effects between Fluoride Awareness Initiatives (FAI), Perceived Risk of Fluoride Exposure (PRF), Community Trust (CT), Adoption of Fluoride Safety Practices (AFS), and Public Health Strategy Effectiveness (PHS). The visual representation provides researchers with enhanced knowledge about variable relations in public health communication strategies. This model shows that Community Trust works as a management factor which improves the relationship between awareness programs toward higher risk perception and safety practice adoption. A tree structure illustrates the connections among several components that collectively affect fluoride safety programs through a logical order of relationships.

3. Model and Hypotheses

3.1 Research Model

The research model implements the Health Belief Model (HBM) mechanism because it focuses on health and resulting behavior responses. PRF levels emerge from FAI to produce modifications in individual behavioral responses (AFS and PHS) by means of CT in local health institutions. PaF conducts analysis of community trust in health authorities as a moderator that affects the relationships between FAI and perceived risk then verifies these patterns through its examination of community trust. The research model hypotheses appear in Figure 3.

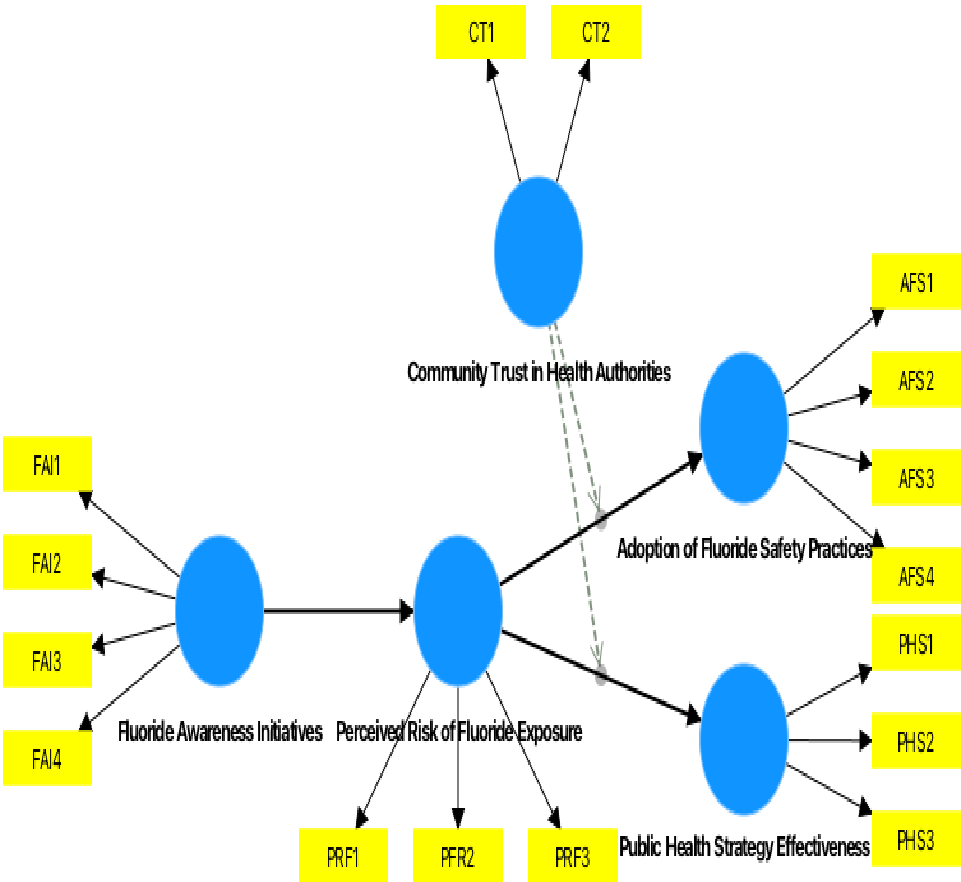


Figure 3: Research Framework

3.2 Fluoride Awareness Initiatives and Perceived Risk of Fluoride Exposure

The model begins with fluoride awareness initiatives (FAI) that affect how individuals perceive their fluoride exposure risk PRF. Several investigations have demonstrated that people understand risks better because risk awareness directly influences how they view health threats [30]. When fluoride awareness efforts expand the information pool about fluoride dangers the risk perception of individuals toward fluoride exposure will increase. As per the Health Belief Model (HBM) the degree to which someone perceives being vulnerable to health threats affects their conduct [31]. Thus, we hypothesize the following:

H1:The implementation of fluoride awareness initiatives (FAI) leads to a positive change regarding the perceived risk of fluoride exposure (PRF).

Enhanced fluoride awareness obtained from public health campaigns and educational programs and informational efforts leads people to understand fluoride represents a potential health danger.

3.3 Perceived Risk of Fluoride Exposure and Behavioral Intentions (Adoption of Fluoride Safety Practices and Public Health Strategy Effectiveness)

Our model evaluates the relationship between perceived risk (PRF) when examining its effect on fluoride safety practices (AFS) along with public health strategies (PHS) effectiveness. The theory of planned behavior [32] explains that people base their actions on their evaluations about the behavior and their beliefs about what others think and their self-perceived ability to perform it. People who notice significant dangers from fluoride consumption will show greater willingness to implement safety measures preventing those risks. Public health strategies succeed better in situations where people consider fluoride to be dangerous. Such findings enable us to develop the following assumptions:

H2a:People who identify more risks within fluorine exposure tend to practice enhanced fluoride safety practices (AFS).

H2b:The public health strategies achieve higher effectiveness when communities regard fluoride exposure as a significant risk.

Increased perceptions of fluoride exposure hazards drive people to use more fluoride safety measures and improve public health achievement.

3.4 The Moderating Role of Community Trust in Health Authorities

Community trust in health authorities serves as a determining factor which adjusts both the relationship between fluoride awareness initiatives and perceived risk of fluoride exposure and the relationship between perceived risk and effective fluoride safety practices and public health strategies. Individuals depend on trust as a fundamental element during information interpretation when making decisions according to the HBM framework [33]. The interpretation of fluoride-related information by communities leads to increased risk perception and behavioral changes when health authorities receive high levels of trust. Therefore, we hypothesize the following:

H3:Community trust in health authorities exists as a moderating variable between fluoride awareness initiatives and perceived risk of fluoride exposure so that the strength of their connection increases among communities having high trust.

In communities demonstrating high trust in health authorities (CT) the link between perceived risk of fluoride exposure (PRF) and both fluoride safety practices (AFS) and public health strategy effectiveness (PHS) remains stronger. The research models propose that public health authorities enjoy greater success with fluoride educational initiatives and fluoride safety practice utilization because high trust conditions strengthen the connection between these elements.

3.5 The Mediating Role of Perceived Risk of Fluoride Exposure

Our research design contains hypotheses which demonstrate how perceived risk of fluoride exposure (PRF) functions as an intermediary factor between fluoride awareness initiatives (FAI) and both fluoride safety practices (AFS) and public health strategy effectiveness (PHS). Through the mediation model fluoride awareness initiatives modify individual perceptions about fluoride exposure risks that subsequently drive their behavioral responses supporting public health actions. Research by Li, Yan [34] supports the HBM framework since they find perceived risk plays an essential role for health behavior modification. We hypothesize the following:

H4a:Public health strategy effectiveness (PHS) receives its influence from fluoride awareness initiatives (FAI) that manipulate perceived risk of fluoride exposure (PRF).

H4b:Public awareness about fluoride leads to perceived risk about fluoride exposure which determines the adoption of fluoride safety practices

The hypotheses define fluoride awareness initiatives as instruments which utilize perceived risk to influence both public health results and personal fluoride safety practices.

Table 2: Constructs and Measurement Items

Construct	Items	Sources
Fluoride Awareness Initiatives (FAI)	FA1: Awareness of fluoride risks	[18]
	FA2: Knowledge about fluoride's benefits	
	FA3: Exposure to fluoride-related health campaigns	
	FA4: Perceived effectiveness of fluoride education programs	
Perceived Risk of Fluoride Exposure (PRF)	PRF1: Perceived severity of fluoride risks	[35]
	PRF2: Perceived susceptibility to fluoride-related health issues	
	PRF3: Perceived harmful effects of fluoride exposure	
Community Trust in Health Authorities (CT)	CT1: Trust in health authorities' fluoride information	
	CT2: Trust in government health policies regarding fluoride	
Adoption of Fluoride Safety Practices (AFS)	AFS1: Usage of fluoride toothpaste	[36]
	AFS2: Drinking fluoridated water	
	AFS3: Following fluoride health recommendations	
	AFS4: Regular dental check-ups for fluoride-related issues	
Public Health Strategy Effectiveness (PHS)	PHS1: Awareness of community fluoride programs' success	[37]
	PHS2: Perceived benefits of public fluoride health initiatives	
	PHS3: Public engagement with fluoride safety campaigns	

4. Methodology

4.1 Measures

This study examines five essential constructs including fluoride awareness initiatives (FAI) and perceived risk of fluoride exposure (PRF) together with community trust in health authorities (CT) as well as adoption of fluoride safety practices (AFS) and public health strategy effectiveness (PHS). The constructs receive measurement through various individual items to establish both content validity and precise assessment. Survey items originated from established scales except for information avoidance intention which required the development of new measurement due to unavailable validated tools.

The three items in the Fluoride Awareness Initiatives (FAI) measure how much respondents engage with fluoride awareness programs and their impressions about the programs' fluoride knowledge advancement capabilities. Researchers developed these items after studying previous studies in public health campaign research [18].

The Perceived Risk of Fluoride Exposure (PRF) utilizes three items which researchers adopted from studies about fluoride-related health risks [35]. People use these evaluation tools to assess both the dangerous potential of fluoride exposure and the extent of those risks. CT uses three items to assess trust levels toward health authorities together with government health agencies and experts delivering fluoride-related information. [38] provided the foundation for modifying the items that appear in this study.

This section evaluates Adoption of Fluoride Safety Practices (AFS) through three survey items which assess use of fluoridated products and drinking fluoridated water and visiting the dentist for fluoride treatments. Three items constitute Public Health Strategy Effectiveness (PHS) which evaluates respondent perceptions regarding fluoride-related public health program and policy effectiveness. The items used in the assessment originated from research that evaluated public health campaigns according to [36].

Respondents must rate all statements on a measurement scale ranging from 1 (strongly disagree) to 5 (strongly agree) using a five-point Likert type response format. The research included age, gender, education level and fluoride public health campaign experience as control variables to eliminate any potential confounding influences during the analysis.

4.2 Sample and Data Collection

A survey method was utilized to gather data from the Chinese population which centered on WeChat users who were active on this platform. WeChat serves as a perfect gateway to various Chinese demographics since it represents more than 1.08 billion active users every month [39]. Research data collection lasted from NOV 2024 until Jan 2025. Ten undergraduate students from a university in eastern China participated in the study since they frequently use WeChat.

The students assessed the initial survey questionnaire so researchers improved it before gathering primary data. The last survey implementation took place through the WJX Chinese online survey system (https://www.wjx.cn/). The 20 seed investigators made survey distribution possible because they distributed the questionnaire through their social media networks to reach 10 undergraduate and 10 graduate students.

A total number of 270 users responded to the initial survey dissemination. One-hundred-fifty-four responses failed each survey criterion to ensure validity thus 254 responses were included in the final analysis.

The demographic information about respondents appears in Table 3. A majority (69.3%) among those surveyed were university students while 72.8% were within the age range of 18–25 years and the sample featured more male participants (53.5%) than female participants (46.5%). The respondents demonstrated experience between 3 to 5 years (51.6%) and 6 to 8 years (34.3%) using WeChat along with daily usage numbers reaching 56.7% among users.

4.3 Data Analysis

The researcher uses Partial Least Squares Structural Equation Modeling (PLS-SEM) through SmartPLS software to analyze study data. Pls-sem functions as an effective statistical approach used to process analytical models made up of multiple constructs which demonstrate interrelational characteristics while utilizing multiple indicators for measurement purposes [40]. The predictive model under evaluation supports the use of PLS-SEM analysis because it enables the researchers to study associations between fluoride awareness initiatives and fluoride exposure risks together with community trust elements and fluoride protection measures.

Measurement Model Assessment

As a first step for data analysis we will evaluate the measurement model to determine the reliability and validity of our construct evaluation items. The assessment will evaluate internal consistency and also verify convergent validity and demonstrate discriminant validity.

The researcher will use Cronbach's Alpha and Composite Reliability (CR) to check internal consistency reliability of measurements. The selected methods enable researchers to confirm that all measurement items align with the fundamental concept in their construct. When the Cronbach's Alpha measurement exceeds 0.70 accuracy standards researchers consider the construct measurement items to be reliable. A Composite Reliability value superior to 0.70 signifies strong internal consistency in measurement according to Hair, Risher [41]. Factor loadings are shown in detail in table 4.

Average Variance Extracted (AVE) values will serve as the basis to evaluate convergent validity between constructs. AVE shows the percentage of indicator variability which the construct successfully extracts. Good convergent validity emerges from an AVE value above 0.50 since this indicates that the construct accounts for more than 50% of indicator variance [42]. Table 4 presenting graphical model of the reliability of the study.

The assessment of construct discrimination validity will be done through the combination of Fornell-Larcker criterion alongside the Heterotrait-Monotrait (HTMT) ratio. For a valid construct measurement based on the Fornell-Larcker criterion the AVE square root value should exceed all relationships linking the construct to other constructs. The assessment of construct distinctness requires an HTMT ratio value below 0.90 based on Henseler, Ringle [43] research.

Table 3: Demographic Information of Respondents.

Demographic Variables	Frequency (%)
Age Group	
18–25 years	72.8%
26–35 years	15.0%
36–45 years	9.2%
46–55 years	2.5%
56+ years	0.5%
Gender	
Male	53.5%
Female	46.5%
WeChat Usage Experience	
3–5 years	51.6%
6–8 years	34.3%
9+ years	14.1%
Frequency of WeChat Use	
Several times a day	56.7%
Once a day	31.3%
Less than once a day	12.0%

Table 4: Cross Loadings

Constructs	Items	Factor Loading	CA	CR	AVE
Adoption of Fluoride Safety Practices	AFS1	0.880	0.836	0.890	0.671
	AFS2	0.806			
	AFS3	0.788			
	AFS4	0.798			
Community Trust in Health Authorities	CT1	0.867	0.776	0.897	0.813
	CT2	0.935			
Fluoride Awareness Initiatives	FAI1	0.887	0.848	0.898	0.688
	FAI2	0.819			
	FAI3	0.789			
	FAI4	0.818			
Public Health Strategy Effectiveness	PHS1	0.892	0.822	0.894	0.737
	PHS2	0.819			
	PHS3	0.863			
Perceived Risk of Fluoride Exposure	PRF1	0.895	0.836	0.901	0.752
	PFR2	0.837			
	PRF3	0.869			

Table 4: Heterotrait-Monotrait Ratio (HTMT) The Measurement Model discriminant validity relies on results from the Heterotrait-Monotrait Ratio (HTMT) presented in Table 4. HTMT serves as a criterion which helps determine the distinction between study variables. When the value exceeds 0.9 it indicates that the constructs lack enough distinction to measure different concepts. A value lower than 0.90 shows that the constructs maintain discriminant validity by displaying separation between them [44]. The numbers in this table show the HTMT pairwise comparisons between constructs from the study. An HTMT value of 0.352 exists between AFS (Adoption of Fluoride Safety Practices) and the CT (Community Trust in Health Authorities). The measurement of these two constructs shows distinctness because the HTMT value remains below 0.90. The HTMT value measurement between AFS and PHS (Public Health Strategy Effectiveness) indicates 0.416 which exceeds the 0.90 threshold to suggest construct separation. The evaluation of constructs between FAI (Fluoride Awareness Initiatives) and PRF (Perceived Risk of Fluoride Exposure) produces a HTMT value of 0.350. This demonstrates their distinct nature. The measurement model shows excellent discriminant validity because the values presented in Table 5 indicate the constructs measure distinct areas of fluoride awareness and risk communication without producing significant cross-over effects.

Table 5: Heterotrait-monotrait ratio (HTMT)

	AFS	CT	FAI	PRF	PHS
AFS					
CT	0.352				
FAI	0.339	0.216			
PRF	0.349	0.176	0.350		
PHS	0.416	0.299	0.358	0.312	

Table 6 presented below shown Fornell-Larcker Criterion. The Square Root of AVE measurement for individual constructs exceeds their social relationships with other model variables based on this discriminant validity evaluation. Each construct shows uniqueness through this method which also proves that it properly captures its distinctive aspects. The table displays equivalent to the square root of Average Variance Extracted (AVE) values along its diagonal for each construct [45]. The AFS construct has a diagonal value of 0.819 which signifies its square root value of Average Variance Extracted for AFS equals 0.819. The computed AVE value for CT amounts to 0.902 which signifies robustness in construct measurement. The indicators of AFS and CT together successfully describe a substantial percentage of their construct variations. The Fornell-Larcker criterion requires a comparison between the diagonal square root of AVE values and the correlation values found off the diagonal. According to the Fornell-Larcker criterion the value of AFS (0.819) exceeds correlation values associated with CT (0.294) and FAI (0.289) and PRF (0.298). The results establish AFS as a construct which distinguishes from other variable sets. The value of 0.902 shows up on the diagonal of CT while remaining above the correlation values of 0.180, 0.145 and 0.248 with FAI, PRF, and PHS to facilitate discriminant validity. There is evidence from the Fornell-Larcker criterion that demonstrates both construct uniqueness and proper capture of individual construct variations within the model.

Table 6: Fornell-Larcker criterion

	AFS	CT	FAI	PRF	PHS
AFS	0.819				
CT	0.294	0.902			
FAI	0.289	0.180	0.829		
PRF	0.298	0.145	0.299	0.867	
PHS	0.348	0.248	0.304	0.262	0.858

The measurement model shows excellent quality and validity because of this result. The model elements demonstrate distinct representation since the main diagonal values exceed the other values.

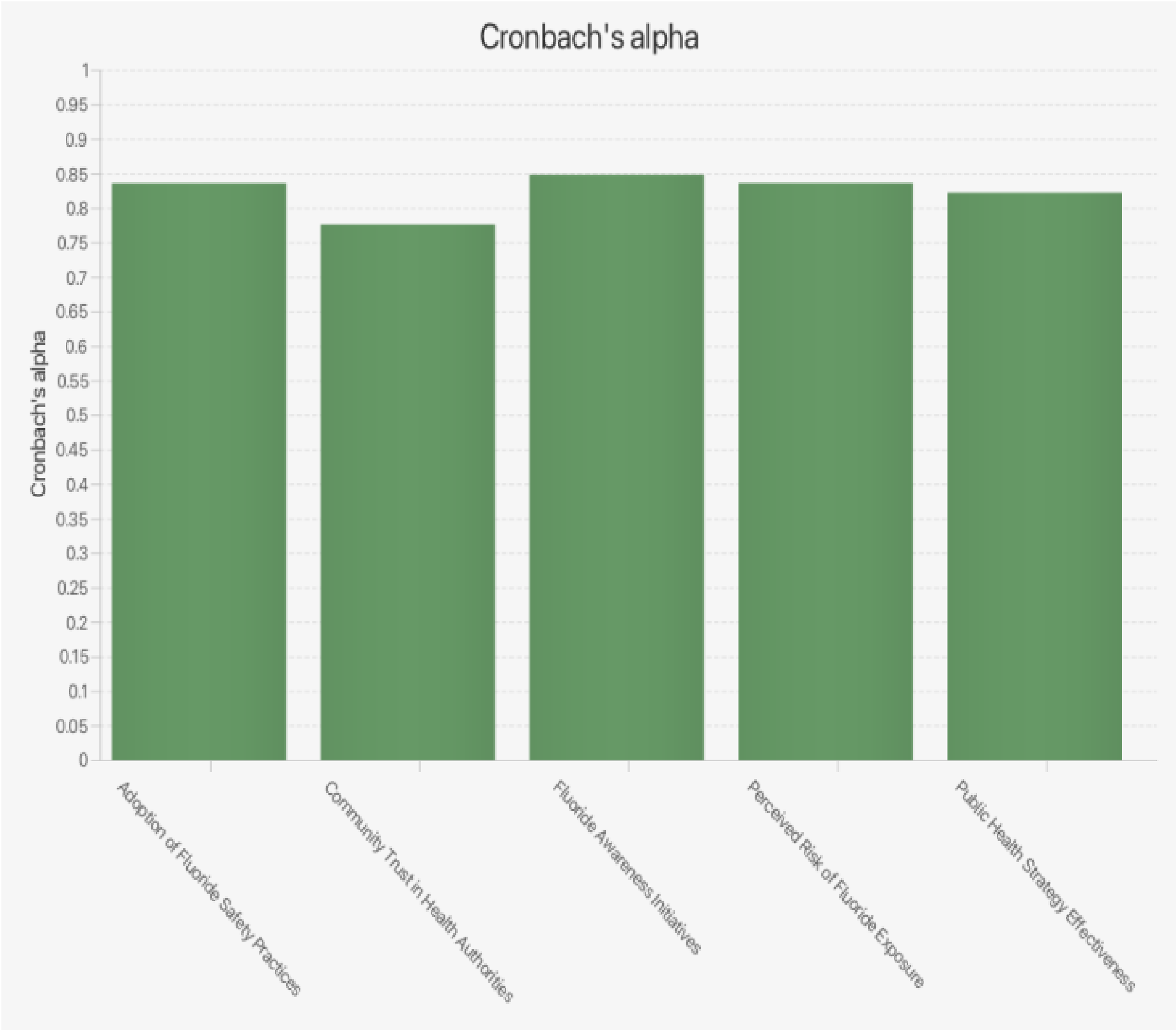
The VIF statistics table presented measures variance inflation factors that apply to variables used in the model formulation. The VIF measurement helps evaluate multicollinearity in predictor variables between multiple sets of variables. The predictor variable shows high correlation with other model components through a VIF score indicating possible multicollinearity that could affect regression analysis results. Assessment based on this table 7 displays the VIF value for each construct variable. The VIF values indicate that the items measure between 1.689 and 2.728. Values exceeding 5 in VIF suggest a possible problem exists with multicollinearity. The values in this table remain below 5 thus indicating that the model lacks significant multicollinearity problems. The model variables demonstrate low correlation among them which permits reliable interpretation for future analysis work.

Table 7: Collinearity statistics (VIF)

	VIF
AFS1	2.669
AFS2	1.689
AFS3	1.799
AFS4	1.741
CT1	1.673
CT2	1.673
FAI1	2.728
FAI2	1.902
FAI3	1.776
FAI4	1.776
PFR2	1.894
PHS1	2.318
PHS2	1.765
PHS3	1.807
PRF1	2.492
PRF3	1.874

The values indicate the extent of construct interdependence and verify that study variables operate independently from each other which promotes analysis reliability.

The measurement model framework shown in Figure 5 serves as the primary device to clarify the construct connections within this research study. The framework depicts the connexions that exist between the five constructs Fluoride Awareness Initiatives, Perceived Risk of Fluoride Exposure, Community Trust in Health Authorities, Adoption of Fluoride Safety Practises, and Public Health Strategy Effectiveness [46]. It can be observed that each construct suits its assessment through precise measurement items according to VIF and collinearity statistics. The multi-collinearity tests demonstrate that the variables have no substantial correlation because the model maintains solid stability. This finding verifies the analysis presented in the model and its validity. The diagram of Figure 4 demonstrates the complete structure between elements.


Cronbach's alpha
Cronbach's alpha
1
0.95
0.9
0.85
0.8
0.75
0.7
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0.6
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0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
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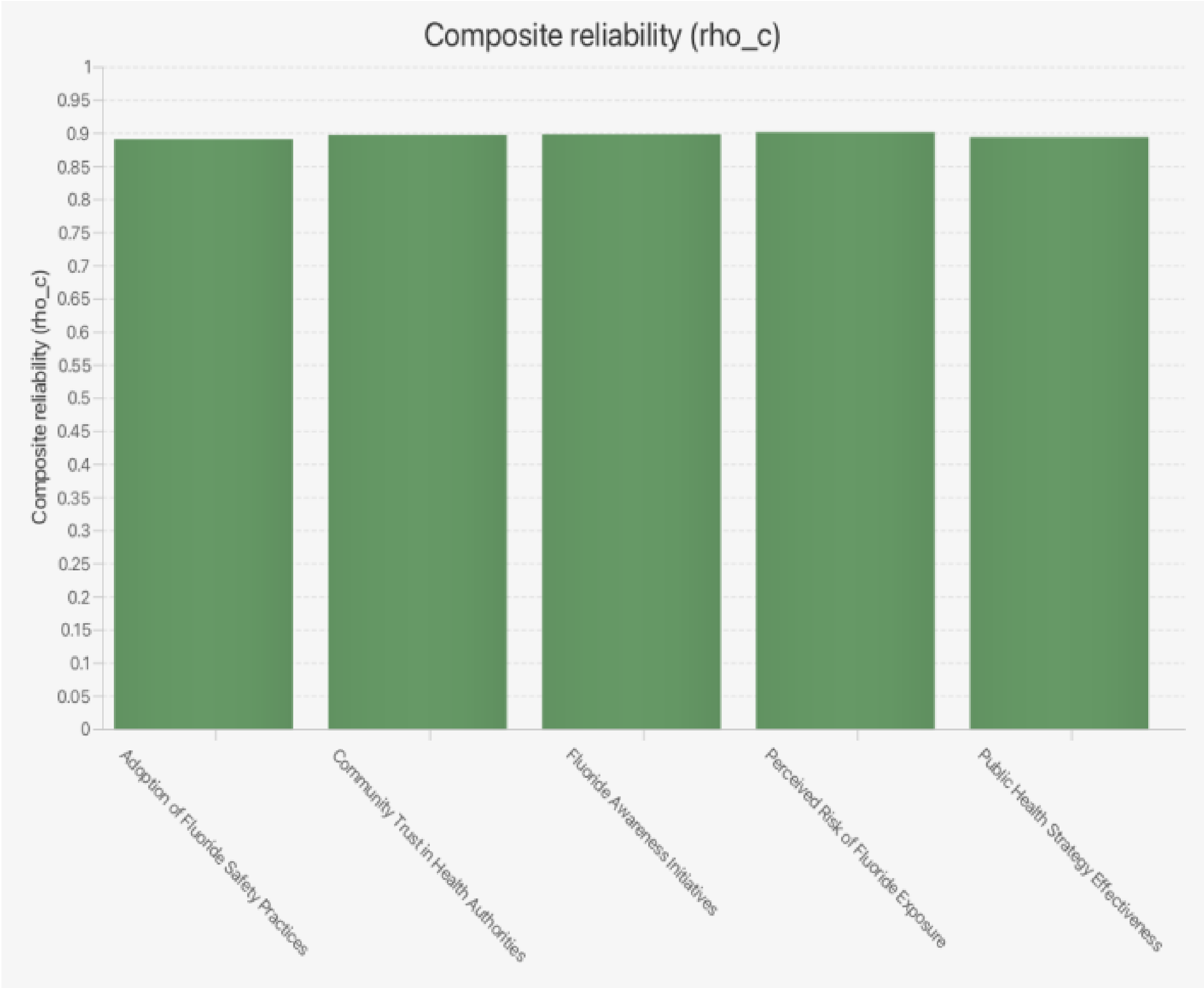
Adoption of Fluoride Safety Practices
Community Trust in Health Authorities
Fluoride Awareness Initiatives
Perceived Risk of Fluoride Exposure
Public Health Strategy Effectiveness


Composite reliability (rho_c)
Composite reliability (rho_c)
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Adoption of Fluoride Safety Practices
Community Trust in Health Authorities
Fluoride Awareness Initiatives
Perceived Risk of Fluoride Exposure
Public Health Strategy Effectiveness

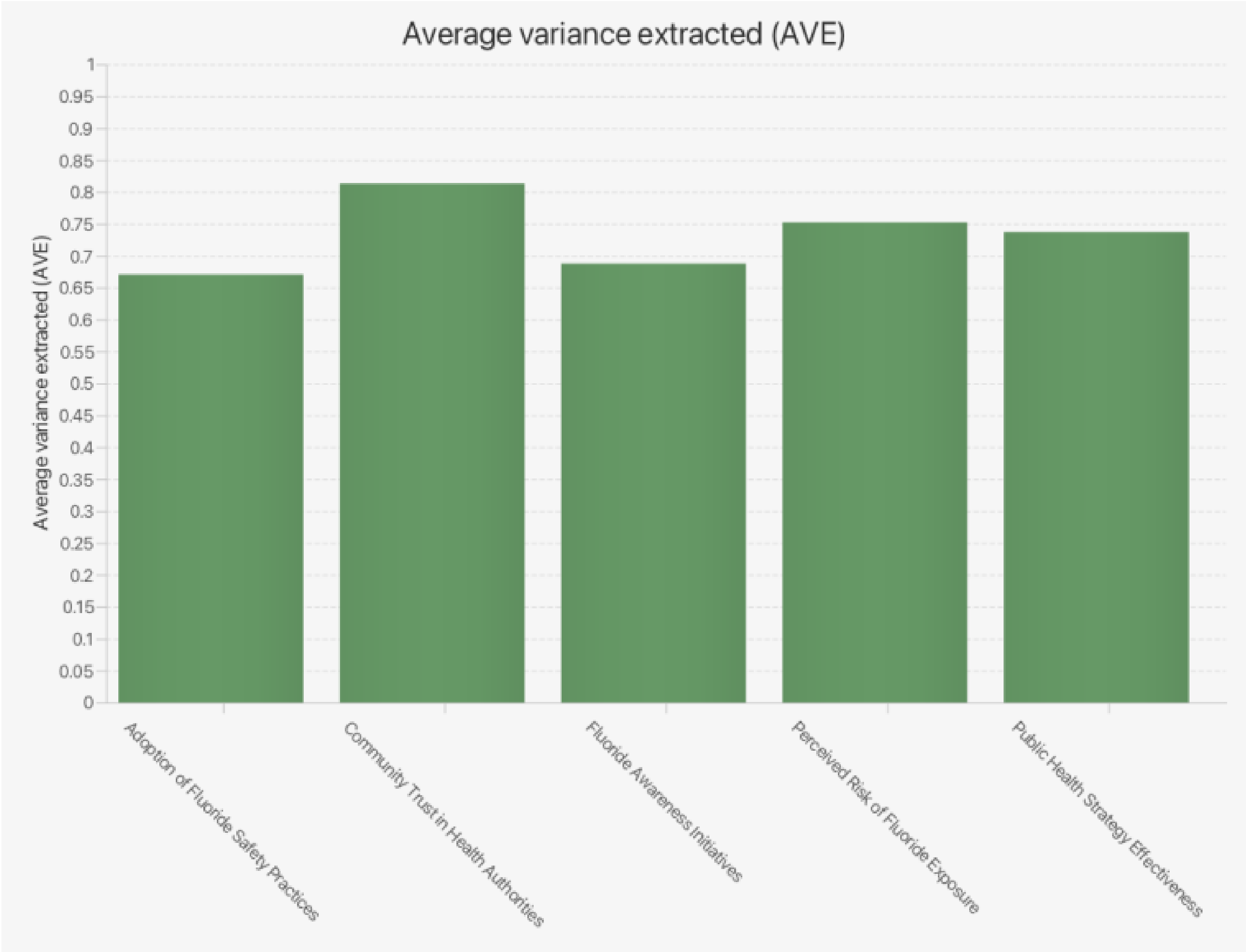

Figure 4: Validity and realibility graph Chart

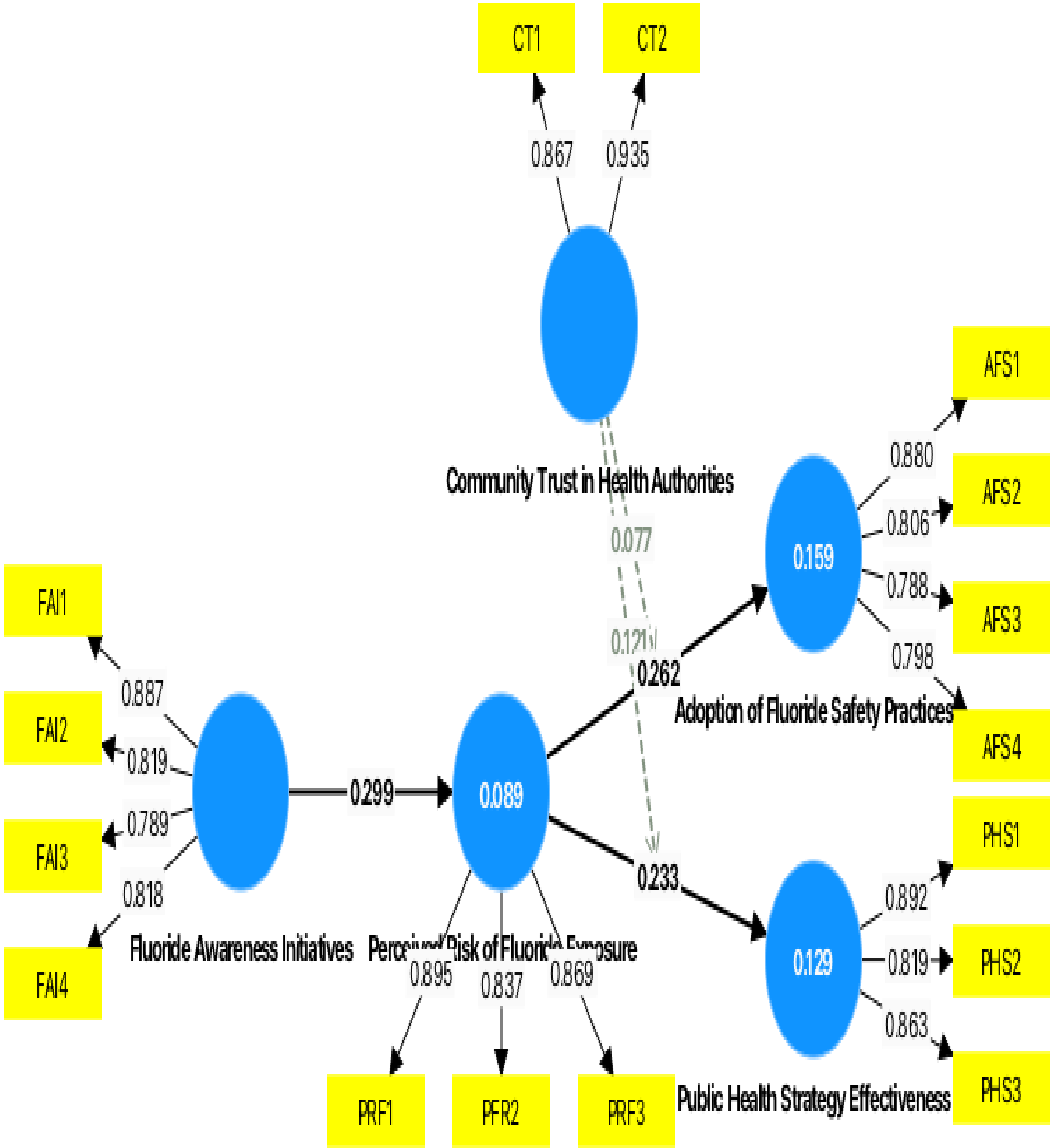

Figure 5: Measurement Model

Model Fit Summary

Structural Model

In this study, the structural model was developed based on the theoretical framework of interconnected networks in fluoride awareness and risk communication. The analysis was conducted using the maximum likelihood estimation method, which is standard for structural equation modeling (SEM).

The model fit statistics for the saturated model and estimated model appear in Table 8. A SRMR value of 0.058 indicates adequate fit because it remains under the suggested threshold of 0.10. Validity measurements of d_ULS and d_G demonstrate that the estimation model fits observed data properly. The NFI (Normed Fit Index) measurement of 0.906 shows an appropriate match of threshold. The Chi-square value (855.463) together with its significance demonstrate that the model provides an adequate fit but shows typical data discrepancies which typically occur in SEM models.

Table 8: Fit summary

	Saturated model	Estimated model
SRMR	0.026	0.058
d_ULS	0.432	1.053
d_G	0.210	0.229
Chi-square	812.497	855.463
NFI	0.916	0.906

RESULTS

The path coefficients alongside significance assessments of all effects and model fitting were used to judge the structural model results. The following results stem from the values observed in Table 9.

The relationship between fluoride awareness initiatives and perceived risk of fluoride exposure resulted in a significant connexion ($p < 0.001$) measured by t-statistic 8.414 with a coefficient of 0.299. Results demonstrate that public outreach focused on fluoride features strongly affects what people think about fluoride risk.

Community trust demonstrated a positive relationship toward fluoride safety practise adoption based on a coefficient value of 0.253 with statistical significance $t = 6.771$ ($p < 0.001$). Research indicated CT as a positive influencer on PHS effectiveness as measured through a coefficient of 0.209 together with a t-statistic value of 5.557 ($p < 0.001$). Permission from community members emerges as essential for attaining successful implementation of fluoride safety practises together with effective public health strategies.

Results showed that increased awareness initiatives directly linked to the adoption of fluoride safety practises with a significance level of 0.001 using a t-statistic of 7.184 ($\beta = 0.262$). The analysis revealed a meaningful connexion between FAI and PHS with a β value of 0.233 and t score of 6.138 ($p < 0.001$) which establishes that public education regarding fluoride safety strengthens public health strategies.

AFS receives a significant impact from community trust combined with perceived risk of fluoride exposure ($\beta = 0.077$, $t = 2.176$, $p = 0.030$) and so does PHS ($\beta = 0.121$, $t = 3.222$, $p = 0.001$). Community trust exists as a moderating factor that changes how fluoride awareness influences the results of public health initiatives. Trust within the community enhances how perceived fluoride risks affect both community members' fluoride safety habits and the successful operation of official public health measures.

Results of the Indirect Effects

Results from the indirect analysis through a structural model reveal how fluoride awareness initiatives (FAI) affect public health outcomes through perceived risk of fluoride exposure (PRF). According to the stated model these are the results for the specific indirect effects:

Fluoride awareness initiatives (FAI) create a substantial positive impact on public health strategies (PHS) effectiveness via perceived risk of fluoride exposure (PRF). The calculated indirect effect stands at 0.069 based on an original sample measurement of 0.071 while its standard deviation measures 0.015 and achieves a significant t-statistic of 4.609 (|O/STDEV|). The effect reaches an extreme level of significance as its p-value stands at 0.000. The amplification of fluoride safety practises results from fluoride awareness initiatives because they make people more conscious about their potential exposure risks [47]. Public health strategies focused on fluoride safety receive better responses from people who recognise major risks in fluoride exposure.

Table 9: Path coefficients

	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values
CT -> AFS	0.253	0.255	0.037	6.771	0.000
CT -> PHS	0.209	0.210	0.038	5.557	0.000
FAI -> PRF	0.299	0.301	0.036	8.414	0.000
PRF -> AFS	0.262	0.263	0.036	7.184	0.000
PRF -> PHS	0.233	0.235	0.038	6.138	0.000
CT x PRF -> AFS	0.077	0.077	0.035	2.176	0.030
CT x PRF -> PHS	0.121	0.120	0.038	3.222	0.001

Fluoride awareness initiatives (FAI) affect the adoption of fluoride safety practises (AFS) by means of perceived risk of fluoride exposure [48] acting as an intermediate variable. The initial analysis shows an indirect effect of 0.078 which has a mean value of 0.079 while its standard deviation reaches 0.015 and the calculated t-value amounts to 5.131 (|O/STDEV|). Statistically meaningful evidence supporting this relationship becomes evident through the p-value of 0.000. The detailed results are presented in table 10. A better understanding from fluoride initiatives drives individuals to see fluoride exposure as more dangerous which leads them to adopt safety-related fluoride practices through using fluoride toothpaste and drinking fluoridated water and adhering to public health guidance. Since perceived risk plays an essential role in addressing both behavioral transformations toward fluoride safety practices as well as public health outcome effectiveness. The increased knowledge about fluoride risks leads to both immediate behavioral changes in addition to strengthening public health campaign effectiveness.The detailed structural model is presented in figure 6 below.

Table 10: Specific indirect effects

	Original sample (O)	Sample mean (M) vslue	St-Dv	T-Stat	P
FAI -> PRF -> PHS	0.069	0.071	0.015	4.609	0.000
FAI -> PRF -> AFS	0.078	0.079	0.015	5.131	0.000

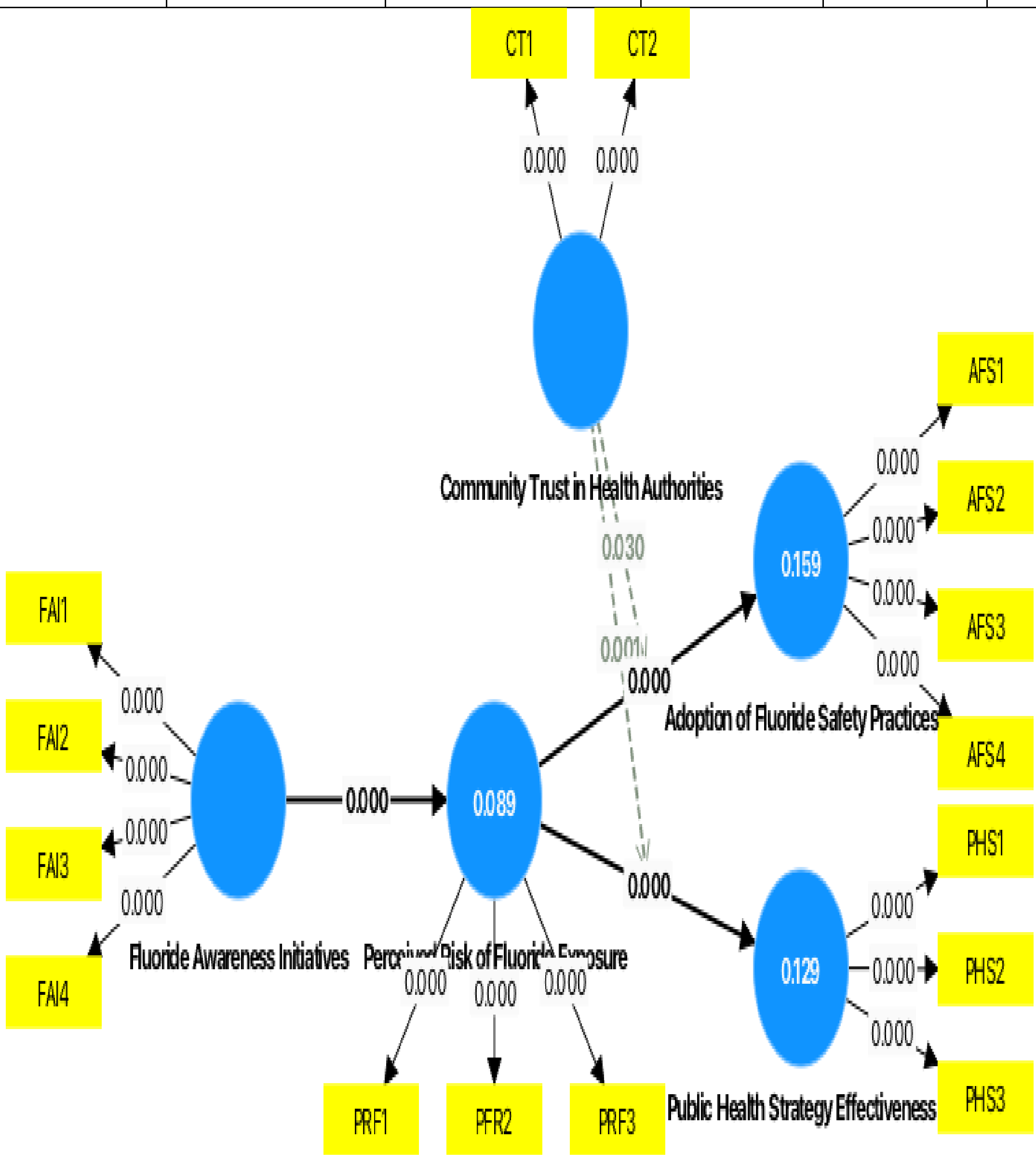

Figure 6: Structural Model

Discussion

The study results demonstrate how education about fluoride moves forward both fluoride safety practise adoption and the effectiveness of public health initiatives. The research data shows that fluoride awareness initiatives produce both positive and significant positive impacts on fluoride safety practise adoption as well as public health strategy effectiveness because public health information drives substantial health outcomes improvements.

The results validate [49] research which proved public health campaigns enhance health risk and benefit awareness to drive behavioural transformation. The implementation of public health campaigns regarding fluoride has reduced dental caries and enhanced oral health while mainly using water fluoridation and fluoride supplementation programmes. Results from the study demonstrate the necessity to keep spreading fluoride-related education which builds awareness about fluoride's positive effects on oral health.

Public health messages demonstrate significant influence on human daily behaviours because people implement fluoride safety practises after receiving awareness initiatives about fluoride [50]. Public knowledge about fluoride importance leads people toward adopting the adoption of fluoride-based dental safety measures including fluoride toothpaste usage and fluoridated water consumption. Public health agencies should persist in backing fluoride educational efforts since these activities foster beneficial behavioural modifications in community settings.

Popular recognition of healthcare institutions (CT) influences how much fluoride awareness initiatives (FAI) impact perceived risk of fluoride exposure (PRF). The effect of fluoride awareness programmes on perceived fluoride risks becomes stronger when community members trust their health authorities resulting in better fluoride safety adoption.

The observed relationship confirms past scholarly work regarding trust as an important factor in health communication. The perception of health authorities by individuals proves essential to determine their interpretation of received health information as well as how strongly they will follow those recommendations [51]. People who place trust in fluoride information sources tend to understand the medical dangers concerning fluoride in their environment. Genuine trust between individuals and health organisations results in better behaviour changes since people follow practises endorsed by organisations they trust.

Public health initiatives need to evaluate both the factual nature of provided information and the trustworthiness of their information sources. Community trust in health authorities will boost the effectiveness of fluoride awareness initiatives which would result in better health outcomes [52]. The solution requires clear communication standards as well as public involvement through health initiatives and formal responses to any public scepticism about fluoride-related information.

When people encounter fluoride exposure risks in their environment their perceptions of these risks (PRF) act as a major link between fluoride awareness programmes (FAI) and people adopting fluoride safety measures (AFS) while enhancing the performance of public health strategies (PHS). People who encounter fluoride awareness initiatives develop increased fluorochemical risk perceptions that guide their fluoride safety practise execution and their support of public health strategies.

The assessment results in the paper demonstrate alignment with the Health Belief Model (HBM) since people form their health-related actions through their understanding of potential health dangers and their impact [53]. This study shows that increased fluoride risk awareness causes people to better understand their vulnerability to fluoride problems thus driving them to use fluoride products and support fluoride-related public health strategies. This study shows that fluoride awareness campaigns create both educational results and modifications in health belief systems since they create behaviour change among community members.

Public health intervention planning demands the inclusion of strategies to address risk perception factors based on the data from mediation tests. Fluoride awareness programmes become more successful when they provide information about protective dental benefits of fluoride but also include details about potential fluoride exposure dangers. Well-constructed interventions which address both information benefits and risks will probably result in better decision quality throughout the population that bridges to improved health results.

Implications

Theoretical Implications

This research adds new knowledge to Health Belief Model literature by showing that perceived risk functions as a vital element which connects fluoride awareness programmes to health practises. The research findings help confirm the crucial role played by risk perceptions within the Health Belief Model according to theoretical models. Fluoride awareness programmes should concentrate on raising public awareness about fluoride exposure thresholds since this breeding of concern will lead people to adopt defensive health behaviour measures.

The research demonstrates why trust levels directed at health authorities determine how effective public health messages become. Health organisation trust stands as a fundamental basis which determines people's responses to obtained health information. This discovery impacts public health initiative design because such initiatives need to work simultaneously on knowledge growth while building trust of information sources.

Practical Implications

This study provides crucial benefits for public health authorities who develop policies as well as implement strategic decisions. Public health benefits from fluoride awareness campaigns whose design intends to raise perceived fluoride exposure risks leading to better health outcomes. Public health authorities should teach people about fluoride benefits alongside its potential risks so people can make aware choices.

The research results demonstrate community trust in health authorities stands as a vital element. Public health agencies must work on friendly trust-building strategies by delivering clear information and involving communities and resolving concerns about fluoride misinformation. Such measures will elevate the impact of fluoride education strategies and produce better health effects.

Limitations and Future Research

This research delivers important findings about fluoride awareness programmes yet researchers identify various constraints within their work. The study foundation depends on self-reported information from participants which might have limitations because respondents could show social desirability bias. The research data might contain inaccuracies because participants either falsely elevated their fluoride knowledge levels or lessened reports about their concerns regarding fluoride exposure. Future research should implement objective fluoride biomarker assessments to cross-cheque self-report data because it will improve measurement accuracy of fluoride exposure.

The research examined only a single defined group of participants (individuals in particular areas or demographic groups) throughout the analysis. The study results cannot be widely applied across different populations because they depend heavily on cultural and socio-economic characteristics of the studied subjects. Further studies must examine the relation between fluoride knowledge and population demographics including different cultural backgrounds in a more broad fashion.

The research design had a cross-sectional structure that blocked investigators from making causal interpretations. Research on fluoride awareness initiatives needs to employ either longitudinal or experimental methodologies to identify sustained effects on health outcomes together with behavioral patterns. An extended study design would allow researchers to reveal the complete effects that fluoride educational initiatives have on public health outcomes.

Conclusion

This research shows how fluoride awareness programmes enhance both the implementation of safety practises relating to fluoride as well as public wellness results. The research findings demonstrate how perceived risk acts to transmit fluoride awareness effects on health practises while communities' trust in health authorities helps to moderate these relationships. The research findings produce critical information that direct developers of public health strategies to enhance fluoride safety measures. Future investigations need to investigate these relationships stronger and study how fluoride awareness programmes impact health outcomes throughout extensive periods.

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