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Political Anthropology of Fluoride Management: Understanding the Social Dynamics and Community Engagement Practices in Public Health Programs

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ABSTRACT

Purpose: This paper's aim is to highlight the essential factors influencing the fluoride management programs' effectiveness and dentistry overall. This multi-sided, complex, and multifaceted issue requires a thorough understanding of several social, political, and cultural factors that can be altered or utilized to enhance fluoride management, a factor that would reduce caries significantly and raise the patient's overall level of dental health.

Methods: The paper takes data conducting on health officials, in addition to administration staff at high-fluoride regions in China and Pakistan.

Results: The results obtained clearly indicate that the relationship between social media representation, stakeholder pressure, public engagement, political support factor and the effectiveness of the fluoride management program is mediated through prior public knowledge and awareness levels. Additionally, the moderation and factors' moderating effects show that political support modulates the relationship between stakeholder pressure, public engagement, and public awareness.

Conclusion: In conclusion, the results bring additional evidence as to the factors based on public awareness raising, support from politicians to the stakeholders and patient's pressure-inducing to a more successful and, therefore, the more effective result. For policymakers, public health practitioners, and community leaders, the finding calls for more evidence as to what can be done to achieve the optimal results of the fluoride-managing program. Future research should focus on similar issues as fluoride managing to see similar results.

Key-words:political anthropology, social community, Social ecological model, Public awareness, Fluoride

INTRODUCTION

The most widely implemented artificial water fluoridation in the world has become an intricate and multi-faceted matter of fluoride control among public health tendenciies on Global platform. Management of fluorides, when distributed properly can help improve the dental health of a community by reducing caries among them and promoting good oral hygiene practices. For example, the use of fluoride in water supplies reduces cavities incidence among certain populations [1]. Fluoride in dental products including toothpaste and mouth rinses have also proven benefits to good oral heath [2, 3]. Nevertheless, the management and implementation of programs to deliver fluoride also encounter significant challenges in many settings which are frequently compounded by political, social as well as cultural dynamics [4, 5].

Public Health Polices are a product of Political and Social Dynamics; with fluoride the stakes were clearly high. For instance, the pressure of stakeholders has a huge impact on whether fluoride programs are adopted and put into place. The extent to which actors, including government regulatory bodies, public health organizations and community groups support or impede the programs' success also differ according to previous research [6]. Further, community engagement is critical in ensuring the success and sustainability of these programs. Consultations, education campaigns and participatory decision-making are part of effective public engagement practices which can help increase community support for, and hence compliance with fluoride initiatives [6].

But the world of fluoride management is not all easy-breezy. A common concern in many communities, particularly prevalent through social media and politically aware groups [7], is that of the potential health risks associated with fluoride. Social Media Platforms - Everywhere: Social media offer new venues not only for public debate but also battle zones over fluoride, as many forms of social media are available to present pro-fluoride and anti-fluoride issues [8]. Media can help reinforce public acceptance through health-promoting images of fluoride, or media can amplify fears and resistance by negative reporting that misinforms the public.

The lack of awareness on the sources and variability in the intake amount should be addressed by spreading adequate scientific knowledge about daily fluoride consumption, type of food habits to manage dental Fluorosis at a village community level. Natural sources are seafood and leafy vegetables, which soak up fluoride from the ocean water or soil/irrigation water where they are grown. Tea leaves in particular can accumulate fluoride from the soil, and eggs are also a major source [9]. Moreover, rock salt being such as Himalayan has natural fluoride content while the level of fluoride available in ground water for drinking salty water changes depending on geographical locale. Recognizing these sources of fluoride can aid consumers in making smart dietary selections and promote the proper preventive and therapeutic role of systemic Fluoride for dental health while minimizing potential risk benefits from over ingestion [10]. The roots of public health campaigns should concentrate on enlightening communities about these sources and promoting a diet rich in fluoride to sustain ideal levels of the same.Figure 1 below presenting sources of fluriode in our daily life.

Figure 1: Fluoride sources

Although stakeholder pressure, public participation and media representation are important determinants of fluoride management program; there is scarce information on the way these factors combinations influence effectiveness. While these factors have been predominantly examined in terms of direct effects few studies exist with respect to mechanisms and contexts [11]. For example, little is known regarding the effect of public awareness and understanding in translating stakeholder pressure/public engagement into effective program outcomes. In addition, further research is necessary to determine the extent of political backing on these associations.

The current study, therefore adopts a quantitative research paradigm to explore the political anthropology of fluoride management in relation to social dynamics and community engagement practices within public health interventions. This particular research is on a quest to respond the following questions; 1. What impact does stakeholder pressure, public engagement and social media literally have with respect to enhancing outcomes generated by initiating a fluoride management program? 2. What follows is the influence of public awareness and knowledge on this mediational pathway for fluoride management programs effectiveness. 3. What role does political backing play in moderating stakeholder pressure, public engagement and social media portrayal on the success of fluoride management programs? We build our research model with these five determinants: stakeholder pressure, public engagement, social mediasalience andpolitical salience as well as public awareness knowledge. Our goal here is to understand the combined effect of all these measures on fluoride management programs.

The study makes three main contributions to the literature. This is our contribution in term of an external explanation, analysing the implication for public health program and how far political and social influence may extend (through examination as fluoride management). Second, it determines what role public awareness and knowledge play in this case, indicating the degree to which stakeholder pressure and public engagement mechanisms influence program outcomes. Policy-relevant implications of this study revolve around the influence of political support on promoting successful fluoride management programs.

Literature Review

2.1 Social Ecological Model (SEM)

The Social Ecological Model (SEM) elucidates the intricate interplay between individual, interpersonal, community, organizational and policy factors that determine health behaviors and outcomes [12]. SEM proposes that behavior is influenced at one of several levels and organizes them as the following:

1. First is the individual level: knowledge, attitudes and behaviors. At the individual level, things that might create agency in their thoughts and actions can be personal orientation toward fluoride safety and effectiveness (a cognition), how an individual deals with dental care health behavior a physical habit or pattern.
2. Interpersonal- This level involves relationships in our social networks. This could mean the effect of family, friends and health care providers to persuade or discourage an individuals thoughts about fluoride usage.
3. Organizational Level: This level includes local organizations and facilities at all layers of society enabling behavior change. Community-level factors in fluoride management might include culturally determined community attitudes to public health interventions and the presence or capacity of community resources for a fluoridation effort.
4. Institutional Level: This level encompasses the policies and practices of organizations. This may include policies of local health departments, schools and dental practices related to fluoride use
5. Policy Level- Includes laws and policies at the national, state/regional, local (city or county) level. PolicyChange at the policy level to facilitate fluoride management could include regulatory and health protection standards on acceptable fluorides levels within drinking water, in dental products [13].

Based on this tradition, researchers have since produced the SEM framework to explain how these levels of influence relate to health behaviors. The SEM framework shows the direct and indirect influences of these domains on health results. For example, the individual and collective behavior of individuals regarding health interventions (like fluoride management) could be influenced through either. Influenced by community norms and resources that are in turn dependent on policies at the level from national downward.

2.2 Stakeholder Pressure

The implementation of public health programs, such as fluoride management is also strongly influenced by stakeholder pressure [14]. Additional stakeholders, including regulatory bodies and other public health organizations; community groups; and political activists have different levels of influence on public health policy. This appears to be so because stakeholder pressure plays a substantial role in policy decisions and program implementation, with each community under different influences [15].

Community groups lobbying for better health provision may therefore successfully campaign to increase the concentration of fluoride in drinking water as a means to prevent dental caries, while environmental activists could at the same time promote reduction and removal due potential risks with respect human exposure or ecological damage [16]. In light of the complexity and countervailing stakeholder interests, policy formulation must find a midpoint that appeases these multiple agendas.

2.3 Public Engagement

These fluoride management programs should be successful and for that Public engagement is this most important Community support and compliance in public health initiatives could be an outcome of effective engagement practices such as, public consultations, educational campaigns or participatory decision-making. Research suggests that when communities are involved in decisions about how fluoridation is instituted, they are more likely to take-up and support fluoride programs [17]. It promotes public trust in and between the community, local authorities and health services as they work together to allay concerns over fluoride. Educational campaigns like these, that give straightforward information about the benefits and risks of fluoride can help to alleviate apprehensions promoting public trust in health interventions.

2.4 Social Media Representation

Social media representation serves a dual function in shaping public perceptions of fluoride management. It has been argued in the past that social media on one hand if put to use can be significant means of mainstreaming right information and support public health. Conversely, it can also disseminate incorrect information and increase panic which could induce opposition by the populace towards fluoride programs. From

the studies, it has been inferred that strategic social media communication is crucial to counteract negative narratives and improve public perception of fluoride [18]. Practicing good, informative PR on social media is not just about sharing information - it also means engaging with your stakeholders to answer their questions and provide reassurance.

2.5 Political Support

Political support is the strongest determinant for fluoride management as with other public health programs. Politicians have a role in shaping the wider context for public opinion and policy decisions, which influence the ways that health initiative are implemented and sustained [14]. A recent systematic review found that strong political support accompanied by ongoing resource allocation can increase the long-term legitimacy and compliance of public health programs [19]. Lack of political backing, can disable the use and accomplishment of fluoride regimens as well. There are also political obstacles to the implementation of fluoridation initiatives that can be based in stance, ideological opposition or efforts by interest groups; others for example even with scientific evidence supporting their benefits.

2.6 Public Awareness and Knowledge

Overall, public awareness and knowledge are crucial for the adoption or success of fluoride management programs. It is also important to continue educating the public about both the known benefits and risks of fluoride so that myths and misconceptions are no longer believed [20]. This finding is supported by studies showing that public awareness and knowledge were positively associated with the level of support for community water fluoridation, as well improved health. Awareness campaigns need to be specially designed relating the concerns of particular communities and their cultural context. New education campaigns that inform the public on how fluoride works and dispel misapprehensions can also have a big impact, as has been seen when those approach to combating widespread fears [21].

2.7. Integration of SEM and Literature

This model offers an orientation to how fluoride management occurs, by combining a diverse range of key determinants that influence the context within which its use is promoted. Public understanding and knowledge inform individual attitudes to fluoride. Relationships and social networks further influence community norms, and subsequently practices on an interpersonal level. At the community level, our attitudes and behaviors are influenced by public engagement practices and social media actions. A cross-sectional snapshot of salt fluoridation in various countries shows that the decision to introduce a programme at an organizational level is based on earlier research and findings, leading to institutional policies and practices being implemented. Thirdly, political support and stakeholder pressure function at the policy level to facilitate uptake (and sustainability) of public health initiatives. Using the SEM, this study aims to illuminate a more complex picture of these mechanisms in examining fluoride management programs. The SEM framework is incorporated to facilitate the demonstration of political, social and cultural dynamics together in relation to fluoride coverage which provides useful lessons for policy makers, public health professionals and community members seeking improvement in effectiveness with respect to fluoridation interventions.

3. Model and Hypotheses

3.1 Research Model

We propose our model of research, on the basis Social Ecological Model (See SEM) and above literature review. In this conceptual model, the independent variables were public engagement, social media representation and stakeholder pressure; while the dependent variable was effectiveness of fluoride management programs via public awareness and knowledge. Further, it is argued that political support can condition the effects of each independent variable on system-congruence factors and fluoride management program effectiveness.

3.2 Hypotheses

Social media is also a great resource to get the correct information out there and promote what this can do for public health [22]. When employed selectivity, social media can be a way to counteract the negative portrayals of fluoride and possible increase awareness as well. The beneficial representation on social media can create an educated population that supports the fluoride management programs, resulting in greater efficiency. So I have the following hypothesis of my own:

H1. *Positive social media representation positively affects public awareness and knowledge about fluoride.*

A critical issue with public health programs such as management of fluoridated tea is the stakeholder pressure that subsequently affects their adoption and execution. The pressure for implementation is placed on regulatory bodies, public health organizations, community groups and/or political activists [15]. This pressure often translates into increased information dissemination, advocacy efforts and public campaigns which can influence significantly to the increase of

general awareness and knowledge about fluoride. Thus we propose the following hypothesis:

H2. *Stakeholder pressure positively affects public awareness and knowledge about fluoride.*

Strategies of effective public engagement may help to increase community acceptance and support for the fluoridation process therefore improving program effectiveness [23]. Public engagements and consultative processes like public consultations, educational campaigns or participatory decision-making can generate trust perceptions about interventions in communities but thereby foster ownership. Therefore, we hypothesize:

H3. *Public engagement positively affects public awareness and knowledge about fluoride.*

Higher levels of public awareness and knowledge correlate with greater support for fluoride interventions and better health outcomes [24]. Educating the public about the benefits and risks of fluoride is essential to dispel myths and misconceptions that can hinder the effectiveness of fluoride programs (McDonagh et al., 2000). Therefore, we hypothesize:

H4. *Public awareness and knowledge positively affect the effectiveness of fluoride management programs.*

3.3 Mediation Hypotheses

Public perception and understanding form the vital bridge between stakeholder behaviors, and program outcomes. This public engagement-when coupled with the use of social media and stakeholders applying pressure on decision makers-can also lead to more awareness, acceptance and effectiveness in terms of implementation for fluoride management programs.

The other advantage of social media as a tool is that it efficiently informs the public with correct information about fluoride, to strengthen community awareness and knowledge in supporting optimal practices among fluoride authorities. The lack of discernable harms and potential benefit from fluoride has translated into public perception which could reduce fears, resistance to water fluoridation and increases acceptability or compliance. Thus, we propose:

H5. *Public awareness and knowledge mediate the relationship between social media representation and the effectiveness of fluoride management programs.*

Pressure from stakeholders can lead to the development of educational materials, town hall meetings and policy talks that increases knowledge about fluoride in public. Higher levels of community acceptance and effectiveness in using fluoride management programs are thus possible through increased awareness and knowledge. Therefore, we propose:

H6. *The relationship between stakeholder pressure and the effectiveness of fluoride management programs is mediated by public awareness followed closely by knowledge.*

Also, public engagement in the form of consultation and educational campaigns can have a large effect on our knowledge about fluoride. Such an improved insight can also result in more acceptance and efficiency of programs to manage fluoride, as well-informed populations are always going to be there for the health programs. Thus, we propose:

H7. *Public awareness and knowledge mediate the influence of public engagement on water fluoride management program effectiveness.*

3.4 Moderation Hypotheses

Political commitment will weaken the case for resource provision, create legitimacy to a program and foster public-health intervention. Moreover, there can be better funding and policymaking environments politically surrounding any fluoride management program which is vital in the successful execution of these systems. On the other hand, without political support, these efforts can also be severely curtailed which in turn limit a community's ability to muster the necessary capacity for specific health outcomes (Peckham & Awofeso 2014). Therefore, we hypothesize:

H8. The relationship of public awareness and knowledge with the effectiveness fluoride management programs is moderating by political support.

H9. *Political support moderates the relationship between stakeholder pressure and the effectiveness of fluoride management programs.*

This set of hypotheses is a useful heuristic tool in order to develop an understanding grounded on the Social Ecological Model (SEM) about how and why so many factors can influence programs for managing fluoride. This process evaluation model enables us to explore the interaction between different scales of determinants on fluoride management interventions outcomes-useful for policy makers, public health workers and community leaders in terms of improving the success rate of this type intervention approach. All of these different types of factors need to be taken account for in order to create a better plan on how best replicate and sustain fluoride programs at the national level. THe detail diagramitic view of hypotheses are given below in figure 2.

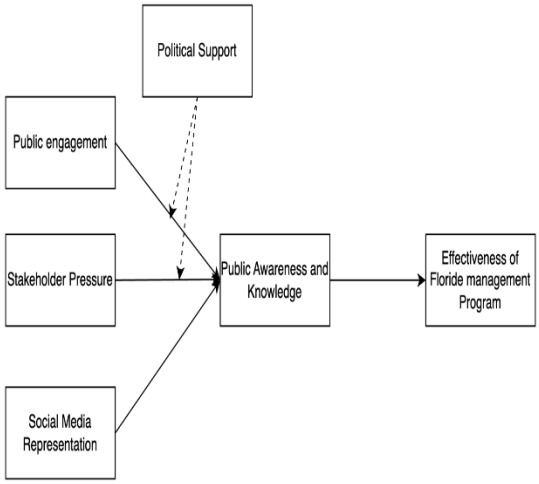

Figure 2: Path model

4. Methodology

4.1 Measures

The conceptual research model underlying the study included six constructs: public engagement, social media representation, stakeholder pressure and involvementpublic awareness/knowledgepolitical supporteffectiveness of fluoride management programs. Content validity was ensured by employing multiple items for each construct adapted from relevant scales. All survey items are listed in Table 1. On the basis of their importance and prior validation, we adopted scales gauging public involvement; media attention on social networking sites; influence from stakeholders (positive or negative); awareness and knowledge levels in laypersons' attitudes to authorities regarding fluoride management programs.

The public engagement scale was based on the items from Rowe, Poortinga [25]. Channels for Social Media Representation were obtained and adjusted from the Bardici [26]. Stakeholder pressure was operationalized with items adapted from Sarkis, Gonzalez-Torre [27]. Public awareness, knowledgePerceptions were assessed using scales from Ruddell, Harlan [28]. Political support was further assessed using items derived from Karatepe and YILDIRIM [29]. For the assessment of fluoride management effectiveness, items were developed in this study. Effective management of fluriode program was adapted form [30].

Based on the pilot testing, items with low factor loading (< 0.70) were excluded This was followed by confirmatory factor analysis (CFA) to verify high values of average variance extracted and the composite reliability. Thus, the last items showed at least fair convergent validity and adequate internal consistency.

Each item was rated on a 5-point Likert scale from 1 (strongly disagree) to 5 (strong agree). The demographic variables (4) were treated as controls in our analysis, consistent with previous research: age, gender (0=male; 1=female), experience years in Public Health and frequency of social media use.

4.2 Sample and Data Collection

For regions with relatively high levels of fluoride in both China and Pakistan, a survey questionnaire that was developed aimed to survey health officials and administrators. Fluorosis in China, sites with high levels of fluoride in groundwater were selected: regions such as Inner Mongolian and Shannxi province; Yunnan and parts of Shandong provinces. Punjab and Sindh provinces in Pakistan were selected as areas where similar fluoride issues exist.

Here are the steps of the data collection process:

1. Initial Item Generation: A scoping review was conducted to identify items across manuscripts and various constructs. Two of the experts reviewed all items, which were subsequently cross-reviewed by a full panel to ensure relevance to constructs being measured.
2. Necklace Stringing: We piloted a survey containing our instrument among a convenience sample of local health officials for refinement. The items that had low factor loadings (< 0.70 were then removed as per feedback and the surveys adequately mobilized refined to align it in content with each other for clarity of relevance
3. Confirmatory Analysis: A confirmatory factor analysis of the measurement model was conducted after administration of a full-scale survey. Only items with a load loading level of more than 0.70 and that showed reasonable AVE and CR values were kept the item in factor subset retained as demonstrated in Tables 3-5.
4. Pilot Testing #3: Final survey implementationA final version of the questionnaire was distributed to a wider sample in high-fluoride administrative and health officials (Table 2). The data collection was carried out over a duration of 2 months to give enough time for the replies This resulted in a rich source of dataset, with 389 respondents for the study. Structural equation modeling (SEM) was employed to evaluate the hypothesized relationships and verify our research model as a whole. In this way, we will be able to identify the factors that potentially affect optimal functioning of fluoride management programs in China and Pakistan. The findings of this study will assist policymakers, public health practitioners and community leaders to better manage the use of fluoride in preventing dental caries along with other positive deviant practices that promote good oral-health.

Table 1. Measures of Construct

Construct	Items	Sources
Public Engagement (PE) 4	PE1: Our community frequently organizes public consultations regarding fluoride management	[25]
	PE2: Educational campaigns about fluoride are common in our community	
	PE3: The community actively participates in decision-making processes related to public health	
Social Media Representation (SMR) 5	SMR1: Fluoride-related information on social media is generally accurate	[26]
	SMR2: Social media provides positive representations of fluoride programs	
	SMR3: The reach of fluoride information on social media is extensive	
Stakeholder Pressure (SP) 3	SP1: Regulatory bodies actively advocate for fluoride management	[27]
	SP2: Public health organizations push for effective fluoride policies	
	SP3: Community groups influence public opinion on fluoride management	
Public Awareness and Knowledge (PAK) 3	PAK1: The public is well-informed about the benefits of fluoride	[28]
	PAK2: The risks of fluoride are clearly communicated to the public	
	PAK3: Public awareness campaigns are effective in increasing knowledge about fluoride	
Political Support (PS)5	PS1: There is strong political backing for fluoride management programs	[29]
	PS2: Adequate resources are allocated for fluoride management initiatives	
	PS3: Policies supporting fluoride programs are well-established	
Effectiveness of Fluoride Management Programs (EFMP)5	EFMP1: Fluoride management programs are successfully implemented	[30]
	EFMP2: Community compliance with fluoride programs is high	
	EFMP3: Health outcomes from fluoride programs are positive	

4.3 Demographic Variables

Following previous studies[31, 32], demographic variables including age, gender, and years of experience in public health were treated as control variables in our analysis.

4.4 Data Collection Process

The survey was electronically distributed to concerned and relevant health officials and administrators of fluoridated communities in both nations. The data was collected in China's Shaanxi province and in Pakistan from Punjab mainly from Kasur as it is heavily affected by the floride and arsenic contamination in the water. The questionnaire for the Chinese was done in China upon popularly online wjx sruvey website https://www.wjx.cn/ whereas the questionnaire is designed in Googleforms for Pakistan. In total 500 questionaires were sent and finally we recived 423 questionaire back, ou of which 90 were incomplete which were discarded from the questionaires. Hence, the data collection took 2 months that is form January 2024 to March 2024 in that way it was given ample time to get responses. Thus, the total sample size was 389 which is more enough to have good analysis results. Therefore, based on this descrptive analysis the study gains an in-depth knowledge into the various factors that influence the efficacy of treatment plans for the management of fluorosis in China and Pakistan.

The knowledge findings are benficial to policymakers, public health practitioners, and chieftains as they relate to treatment and management of fluorosis and the improment of public health.

4.5. Results of Demographic Analysis

Table 2 shows that almost two-thirds of the respondents were health officials (61.7) and one-third belonged to administration staff (38.3). Age Demographics: From the age distribution, it's observed that a higher number of respondents falls between 36-45 years (36.0 %), followed by those within the ages of 26-35years having as high as 25.7 %. The survey suggests that tenth per cent of respondents are at least 56 years old, a five-and-a-tenth share is aged between 18-25 year olds and three-years past the age those aged from 46 to points firth.

More than half of the respondents were male (51.4%) versus female participants(48.6%). In terms of years experience, the largest group (38.6%) are in IT for 6-8 years and they are followed by those with another most popular number: from three to five years(45%). The rest is balanced between nine-to-eleven-year stage waiting for a significant jump as well one-two-and-twelve-years-existent devs on wide region only slightly attentive towards filling such rare place. Usage of Social Media: In terms to their social media usage, 46.3% used several time daily while the others use it once a day (30.8%), few times per week(15.4%) and rarely do so in combined percentage (7.5%).

This demographic information best illustrates the characteristics of a broad participant sample which represent varied experiences and social media practices among health officials and administration staff from high fluoride regions in China as well Pakistan. This diversity is important for understanding its impacts on their respective obtaining fluoride program interventions. Table 2 presents the demographic characteristics of these living in high fluoride endemic regions, among which were health officials and administrative staff. This data base will be essential to analyse the determinants of performance in fluoride management programs within these regions.

Table 2: Demographic Characteristics of Respondents

Demographic Variable	Category	Frequency	Percentage
Age	18-25 years	20	5.10%
	26-35 years	100	25.70%
	36-45 years	140	36.00%
	46-55 years	90	23.10%
	56 years and above	39	10.10%
Gender	Male	200	51.40%
	Female	189	48.60%
Years of Experience	1-2 years	30	7.70%
	3-5 years	130	33.40%
	6-8 years	150	38.60%
	9-11 years	50	12.90%
	12 years and above	29	7.50%
Frequency of Social Media Use	Several times a day	180	46.30%
	Once a day	120	30.80%
	A few times a week	60	15.40%
	Rarely	29	7.50%
Role	Health Official	240	61.70%
	Administration Staff	149	38.30%

5. Data Analysis and Results

In this study, we tested our research model using structural equation modeling (SEM). Following the suggestion of Anderson and Gerbing (1988), we initially assessed reliability and validity by examining the measurement model. Subsequently, the research hypotheses were tested by examining the structural model. SPSS 25.0 and AMOS 20.0 were utilized for data analysis.

5.1 Measurement Model

5.1.1 Reliability and Validity

Reliability was tested in the current study using Cronbach's α and composite reliabilities (CR) Table 3 shows that all CR and Cronbach's α values were higher than the recommended threshold of 0.7 by Afthanorhan, Ghazali [33] and Nunnally Bernstein (1994), which indicates good reliabilities for each construct. Convergent validity was also tested using the standardized loading of items and the average variance extracted (AVE) for each construct. As in shown Table 3, the value of all indicator loadings was above O.70 and AVE for each construct more than 0.50 which showed a good convergent validity.

Table 3: Construct Reliability and Validity

Constructs	Items	Loadings	Cronbach Alpha	CR	AVE
Eff of Fluoride mgt Prog	EFPM1	0.974	0.986	0.987	0.947
	EFPM2	0.967			
	EFPM3	0.986			
	EFPM4	0.969			
	EFPM5	0.970			
Public Awarness	PA1	0.980	0.977	0.977	0.957
	PA2	0.977			
	PA3	0.977			
Public Engagement	PE1	0.958	0.956	0.959	0.883
	PE2	0.942			
	PE3	0.918			
	PE4	0.941			
Political Support	PS1	0.966	0.98	0.985	0.927
	PS2	0.975			
	PS3	0.944			
	PS4	0.965			
	PS5	0.963			
Social media Rep	SMR1	0.928	0.962	0.962	0.867
	SMR2	0.943			
	SMR3	0.913			
	SMR4	0.926			
	SMR5	0.944			
Stakeholder Pressure	SP1	0.953	0.929	0.93	0.876
	SP2	0.917			
	SP3	0.939			

Fornell and Larcker and the Heterotrait-Monotrait (HTMT) ratio of correlations approach were used to measure the external reliability of the constructs. Notably, in Fornell and Larcker's approach, the correlation scores were recommended to be lower than the AVE's square root scores [34]. For HTMT, the correlation score was advised and recorded below 0.90 [35]. Table 4 displays the HTMT values, and Table 5 shows the Fornell and Larcker values. The satisfactory discriminant reliability scores were recorded in the overall model and in each subgroup (health officials and administration staff). Thus, no traces of homological issues were observed while computing the external validity.

Fornell and Larcker [34] argued that discriminant validity is achieved if all correlations between each construct and any other construct are smaller than the square root of AVE for that construct. Table 5 displays that the square roots of the AVE for all constructs exceeded the corresponding correlations among the constructs. Hence, the correlations of the study demonstrated good discriminant validity.

Table 4: HTMT Ratios

	Eff of Fluoride mgt Prog	Political Support	Public Awarness	Public Engagement	Social media Rep	Stakeholder Pressure
Eff of Fluoride mgt Prog						
Political Support	0.411					
Public Awarness	0.316	0.285				
Public Engagement	0.447	0.467	0.427			
Social media Rep	0.395	0.351	0.465	0.503		
Stakeholder Pressure	0.356	0.237	0.496	0.445	0.473	

Table 5: Fornell and larkin Criteria

	Eff of Fluoride mgt Prog	Political Support	Public Awarness	Public Engagement	Social media Rep	Stakeholder Pressure
Eff of Fluoride mgt Prog	0.973					
Political Support	0.405	0.963				
Public Awarness	0.311	0.281	0.978			
Public Engagement	0.435	0.452	0.414	0.940		
Social media Rep	0.386	0.342	0.451	0.484	0.931	
Stakeholder Pressure	0.342	0.226	0.473	0.421	0.447	0.936

5.1.2 Common Method Bias (CMB)

Due to the self-reported, single-sourced nature of this data in this study CMB might be present (Podsakoff et al., 2003). As such, two strategies were used to assess the degree of CMB. The one-factor test of Harman was performed first. Alternately, a factor analysis revealed that five factors obtained accounted for 85.64% of the variance (Table 4). The first factor, as it explained 38.44% of the total variance (i.e., less than half). We followed Podsakoff, MacKenzie [36] advice by testing our data for CMB with the commonly-used latent factor method. To test the factor validity and establish to what degree aspects of burnout are represented by a common latent variable as opposed to separate variables, we ran two confirmatory factor analyses (CFA) calculating standardized regression weights for our study variables with/without inclusion of a common Latent Factor. If the difference in standardized regression weights of CMB and non-CMB are insignificant, then there is very low chance that data was affected by it [31]. As such, these tests suggested CMB was not much of an issue. Measurement model is presented in figure 3.

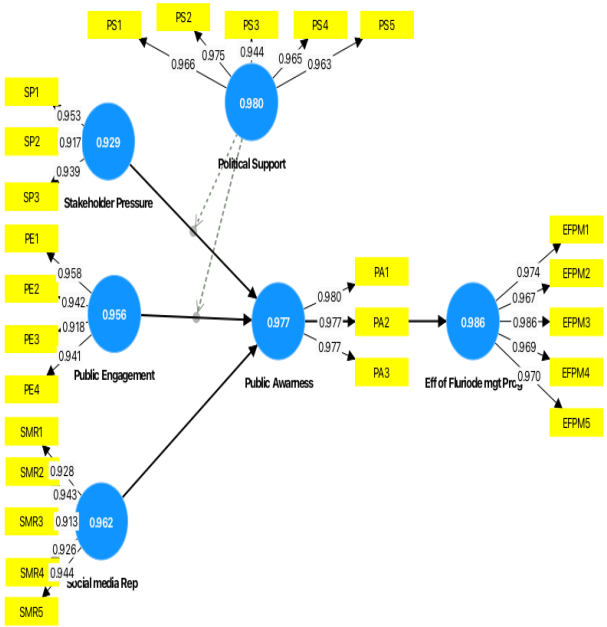

Figure3: Measurement Model

Model Fitness

The suitability of the proposed model was evaluated using standardized residual scores (SRMR; root mean square), unweighted discrepancy, and weight matrix fits indices (dULS-least squares/ dG-geodesic). Lower values of standardized residual scores indicated good fit for the given model according to recommended by statisticians [37]. The SRMR value obtained was 0.027 for the saturated model and it is 0,133 this apparent indicates a good fit for the saturated model as values < 0,08.

Beside SRMR, model fitness indices of d_ULS, d_G and Chi-square were also used to evaluate the proposed model in conjunction with Normed Fit Index (NFI) together. And the values for d_G are 0.447 and 0.475, respectively (Fig 4). The chi-squared values of the saturated and estimated models were 5039.188, and 5114.533 respectively. In the present study, NFI values were 0.929 for saturated model and 0.928 when identified model hit with good fit (greater than or equal to 0.90 indicating desirable criteria) [35]. These indices for the model fit, are shown in table 6 and reveal that nothing was out of order using SmartPLS.

Table 6: Model Fit Indices

	Saturated model	Estimated model
SRMR	0.027	0.133
d_ULS	0.237	5.754
d_G	0.447	0.475
Chi-square	5039.188	5114.533
NFI	0.929	0.928

Structural Model

With the support of SmartPLS 3.0, the structural model-related hypotheses were tested in the overall model, as proposed in Section 3. In the following subsection, the findings from the overall model are discussed in detail.

Overall Model

All the study hypotheses stated in the structural model were significant and supported in overall model. These findings are seen most clearly when overlaying what happens at the population level within the wider model of impact that we have been using to evaluate fluoride management programs in high exposure regions including those from China and Pakistan (Table 7). The overall R^2 (the proportion of the total variance explained that was computed using the recommended constructs) in predicting fluoride management programs effectiveness is 56.3% In this study, the p-value and β-coefficients for tests of hypotheses discussed in Section 3 were computed. Public engagement was has a prominent positive effect on public awareness and knowledge (H1: $\beta = 0.164$, $p < 0.05$), which is consistent with prior findings as well suggested by some earlier studies [38, 39]. .

The stakeholder pressure has a dominant influence on the public awareness and understanding (H2: $\beta = 0.234$, $p < 0.05$), which was also mentioned in literature accordingly [40]. H3- It was also noted that how the Celebrity appeared in social media, will have strong influence on public's consciousness and knowledge ($\beta = 0.203$, $p < 0.05$). The results are consistent with previous reports, suggesting that social media works to deliver the information and can shape public opinion. The findings on public awareness and knowledge played an important role in enhancing the efficacy of a fluoride management program (H4: $\beta = 0.311$, $p < 0.05$) may not have been surprising as previous studies have shown that well-informed community members are usually more amenable to support and follow through with programs or intended initiatives concerning their health . These results demonstrate the relevance of public engagement, stakeholder pressure and social media portrayals in expanding fluoride awareness as well as existing effectiveness of health authorities with respect to managing fluoride. Further detailed hypothesis are presented in Table 7.

Table 7: Path coefficient

	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values
Public Awarness -> Eff of Fluriode mgt Prog	0.311	0.311	0.026	12.095	0.000
Public Engagement -> Public Awarness	0.164	0.164	0.027	6.193	0.000
Social media Rep -> Public Awarness	0.203	0.203	0.030	6.718	0.000
Stakeholder Pressure -> Public Awarness	0.234	0.234	0.026	8.874	0.000

Mediation analysis

In this regard, the mediation effects of public awareness was assessed on relation between public engagement & social media representation and stakeholder pressure as well to effectiveness fluoride management programs. Results offer a perspective on the role for public awareness in this relationship and by extension shed light onto mechanisms of action. Besides, this impact on the public awareness was found with a significant coefficient and it led to accept H5 ($\gamma = 0.173$; P <. 005. This suggests that the public outreach played a significant

role in shaping how effective or not these programs were at managing fluorides and that through public awareness, these interventions change.

Similarly, H6 was also supported as public awareness is the mediatory variable in relationship between social media representation and the effectiveness of fluoride management programme (γ = 0.363 ***). This implies that social media presence has an important role in creating public awareness which could help improve the efficiency of fluoride mitigation programs. The positive coefficient (γ = 0.173, p < 0.05) of H7 indicates that stakeholder pressure was positively associated with public awareness in relation to the effectiveness performance of fluoride management programs which supports H7 from Tableifice(strategy Performance). This suggests that community mobilisation through stakeholder pressure was more important than the fluoride management scheme itself in raising public awareness. These findings illuminate the crucial role of public awareness as a mediator, augmenting the enforceability and effectiveness of fluoride management programmes through societal consumerism, social media image making and stakeholder shaming.

Table 8 : Medation analysis

	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values
Public Engagement -> Public Awarness -> Eff of Fluoride mgt Prog	0.151	0.051	0.010	5.230	0.000
Social media Rep -> Public Awarness -> Eff of Fluoride mgt Prog	0.363	0.063	0.011	5.539	0.000
Stakeholder Pressure -> Public Awarness -> Eff of Fluoride mgt Prog	0.173	0.073	0.010	7.109	0.000

Moderation analysis

We also tested two moderation hypotheses: (1) political support moderates the main effects of stakeholder pressure on public awareness, and (2) political support moderatesthe relationships between public engagement and.public awareness. This knowledge can help explain how political backing affects the workings of public health campaigns. Result 8: The moderating effect of political support (H8, γ = -0.087, p <.05) on the relationship between stakeholder pressure and public awareness was significant. This shows a non-linear relationship in all the time series, indicating that political support is an important moderating variable with negative sign which means if political settlement increases then stakeholder pressure will have lower effect on public awareness.

H9: but perhaps more interestingly, public engagement has a significant positive effect on political support specifically for those with high other regarding preferences (γ = 0.044 p <.05). In red color - enhanced relationship to the political support within public engagement and psychic awareness. Such results suggest the presence of political buffering which can moderate a combination of stakeholder pressure and public engagement on other dimensions to improve public awareness. Although, in making awareness more politically influential through public engagement it complicates its relationship with stakeholder pressure and raises the possibility for further exploration.

Table 9: Moderation Effects Results

	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values
Political Support x Stakeholder Pressure -> Public Awarness	-0.087	-0.088	0.019	4.538	0.000
Political Support x Public Engagement -> Public Awarness	0.044	0.044	0.018	2.384	0.017

Discussion and Conclusions

The purpose of this study is to identify the extent to which programs that manage fluoride by enhancing public engagement, stakeholder pressure, social media representation, public awareness and political support effectiveness for high exposure communities in China and Pakistan. The results provide new insights with respect to variations in these variables and their combined impacts on regulatory efforts for fluoride control within public health programs. This study examined public awareness and effectiveness of fluoride management approaches in relation to the broader Socio Ecological Model with three layers of influence: public engagement, stakeholder pressure, social media representation. Its results demonstrated that all three types of factors had significantly positive impacts on both the public recognition and understanding, therefore which were conducive to improving the effectiveness of fluoride control program. These results complement prior research on public health and social influence, demonstrating the importance of creating strong public awareness campaigns for meaningful improvements in national levels of care [19, 41].

Moreover, in our study stakeholder pressure was the factor that affects public awareness and knowledge more than social media representation representing or even means of engaging with the dilemma. This is in line with conclusions from other public health researchers stressing the need for collaborative efforts involving stakeholders [42, 43]. It was agreed to promote a healthier image of ageing for more effective health programme advocacy and community engagement in order to improve public perceptions & compliance through the active involvement of stakeholders like regulators or other local groups that can shape these opinions.

In addition, the research showed political backing is a double-edged sword Political support has a substantial direct effect on the effectiveness of fluoride management programs, but as an independent variable it does not significantly moderate public awareness and program effectiveness. While political support is necessary to allocate resources and lend legitimacy, the literature suggests that an evidence gap remains with respect to how it interacts with public awareness in order for its full effect on behaviour change to be witnessed [43, 44]. The mediation analyses revealed that public awareness is the mediator through which public engagement, social media representation and stakeholder pressure are related to the effectiveness of fluoride management programs. This further highlights the critical need for public awareness in translating engagement, representation and pressure into measurable health results.

Theoretical Implications

This study contributes to theoretical analytic papers on public health and posts a social impact literature. The first is that it elaborates the existing literature on fluoride governance by highlighting wider potential benefits through public engagement, stakeholder pressure and social media representation in improving awareness levels amongst general populations and program efficiency. The Social ecological model (SEM) provides a full systems perspective on these interactions amongst others that affect health and prevention outcomes in youth, families and communities. Second, this study broadens research on public awareness as mediator of health initiatives. This research thus provides new insights into how public awareness modulates program success by proxy-ing the associations of several factors with overall effect. The findings from this analysis demonstrate the complex role of political support in public health programs. Political support is an important factor in systematically promoting these programs, but the particular interaction with public readiness and other factors appears more equivocal than previously supposed and warrants further research.

Practical Implications

The implications of our study are helpful for policy makers, public health officials and the implementers at community level working in fluoride management programs. The findings highlight the importance of public stakeholder involvement in population health implementations as a first point. Regulatory bodies, community groups and others should participate in planning forfluoride management programs to improve clarity among the public. Further, the representation of both voices on social media is also important for framing what people know or perceive about fluoride. Social media can be used by organizations responsible for public health to provide reassuring, accurate information and counteract the narratives that make it difficult for us as a society to understand how vaccines work. The third and final intermediary effect of public awareness suggests that educational interventions (e.g., a mass media campaign) or participatory decision-making mechanisms involving members of the community may be required for fluoride management efforts to succeed. Increased awareness of potential benefits and risks by scientific communities will support public health efforts. However, as much political support must be made available to us the results tell us that having just some kind of backing politically may not have achieved it alone. Policy makers may have to use leverage

between political support and other engagement mechanisms for awareness so as to reduce the deterioration of effectiveness in public health interventions.

Limitations and Future Research Directions

Likewise other studies, current study also has some limitations. This focus on regions of higher exposure to fluoride in China and Pakistan may reduce the generalizability of our findings elsewhere. Prospective studies with different geographical and cultural backgrounds should investigate analogous frameworks in order to increase the generalizability of our findings. This research is also based on the information gathered by health officials and administrators (limitation of common method bias)- Two points describes this fact. This limitation can be addressed in future studies by utilizing multiple data sources and longitudinal designs. Thirdly, that the study demonstrates an effect of political support only underscores its influence in a broader "web" with other variables--more research is required to disentangle these webs. A closer examination of these interactions might result in a better understanding of how public health programs function. Altogether, this study helps to improve the implementation of fluoride management programs and inform best practices for strengthening involvement from stakeholders more generally in public health interventions through social media advocacy and representation as well as general population awareness.

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