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Connecting Communities: Innovative Communication Strategies for Children's Fluoride Education in Undeveloped Regions

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Abstract

Background: Effective communication and culturally adapted educational content are critical in promoting community engagement and enhancing oral health literacy among children. However, the presence of misinformation or misbeliefs about fluoride can undermine these efforts, leading to reduced knowledge retention and adverse health outcomes.

Purpose: This study aims to investigate the relationships between communication strategies, cultural adaptation of educational content, community engagement, misinformation about fluoride, knowledge retention about fluoride benefits, and oral health literacy among children. Utilizing the HBM framework, the research explores how these factors interact and influence information avoidance intentions within social media contexts.

Findings: Structural equation modeling (SEM) revealed that effective communication strategies and culturally adapted educational content significantly enhance community engagement, which in turn positively affects knowledge retention and oral health literacy. Conversely, misinformation about fluoride negatively impacts these educational outcomes, even within highly engaged communities. Additionally, the interaction between misinformation and community engagement further diminishes knowledge retention and literacy levels. Indirect effects highlighted the mediating role of community engagement in the relationships between communication strategies, cultural adaptation, and educational outcomes.

Implications: The findings underscore the importance of strategic communication and cultural sensitivity in health education programs. They also highlight the critical need for robust misinformation management strategies to safeguard the integrity of health information disseminated through social media. Health educators and policymakers should prioritize developing clear, culturally relevant communication tools and implement measures to counteract misinformation to enhance public health education effectively.

Conclusion: This study contributes to the understanding of how communication and cultural adaptation influence community engagement and educational outcomes in the context of oral health. It emphasizes that combating misinformation is essential for maximizing the effectiveness of health education initiatives, thereby fostering informed and health-literate communities.

Keywords: Communication Strategies, Community Engagement, Cultural Adaptation, Misinformation, Oral Health Literacy

1. Introduction

A double edged sword of communication. Communications strategies can be used effectively to improve individuals, groups and communities, especially on global health challenges. For instance, vaccination awareness raising has been shown to be successful (e.g. [1, 2] as well as promoting sitting prisoners to wash their clothes [3, 4]. Additionally, previous work has demonstrated that participation and culturally adapted and participatory methods expand engagement. These strategies not only accelerate knowledge dissemination but also promote long term behavioural changes in heterogeneous populations.

But many communities, in several cases those in parts that are less developed, obstacles abound in grasping health teaching, comprising of outrageous bends in town transport, linguistic variety, and often predictable cultural obliviousness of standardized transmission models. In this vein, health campaigns utilising traditionally top down approaches commonly fail to resonate with local populations, in part, because contextual adaptation is absent [5, 6]. For this reason, these communities may be under engaged or understand the intended health message poorly.

While many people have acknowledged these challenges, less research has been done on innovative health communication strategies. However, most existing studies tend to speak at large scale health campaigns and neglect community or personal centered approach applicable for particular, neglected populations. Second, some have explored the role of participatory models, however the role of cultural and social factors in determining participatory model effectiveness is scant [7]. Additionally, many of today's existing frameworks tend to focus majorly on promoting general health awareness yet lack depth and do not cover specific topics like fluoride education for kids, which is truly important for long term dental health [8]. This research gap is filled by the present study to develop innovative communication strategies for fluoride education to children in developing countries. Using participatory communication frameworks and culturally adaptive methods, this study investigates how tailored messages can heighten awareness and promote long term health behavior in vulnerable populations.

Three important contributions are presented in this study. It first expands and adds to the body of health communication literature through fluoride education a previously understudied public health topic. Second, the paper makes a case for how community engagement in the design and implementation of communication strategies for underserved environments is essential. It concludes by providing actionable insights for practitioners and policymakers, and a model that closes the gap between theory and practice in health communication.

2. Literature Review

2.1 Health Belief Model (HBM)

One of the most widely used theoretical frameworks in health education and behavior change research is the Health Belief Model. Originally created to explain why people did not engage in preventive health behavior like how people failed to screen for tuberculosis [9, 10]. The HBM focuses on the importance of individual perceptions in guiding health behavior. Yet it has been widely applied over the years to many public health challenges, including smoking cessation [11, 12], vaccination uptake, dietary interventions [13], and others.

The HBM identifies six key constructs that influence health behavior: Rosenstock, Strecher [11], [12] defined aspects of perceived

susceptibility, perceived severity, perceived benefits, perceived barriers, cues to action, and self-efficacy. Perceived susceptibility is an individual's assessment of their risk of getting a health problem. Perceived severity is the thought that the condition is severe as well as its outcome. In concert, these constructs define the perceived threat of an issue with health, and it's the threat that motivates (or attempts to motivate, that is) behavior change. For example, we know that higher perceived susceptibility and severity has been linked to more involvement in preventive health behavior (e.g., regular health checkups; [14].

Further, taking into account perceived benefits and barriers, decision is based on weighing in, the advantage of taking action, against the obstacles or costs in getting it done. Perceived benefits (e.g., improved health outcomes) and perceived barriers (e.g., financial costs, lack of access), have both been found to strongly motivate individuals to adopt preventive measures whereas studies have supported that [15]. An example of this is in the area of dental health, where people are more likely to use fluoride toothpaste or participate in fluoride education programs if they perceive tangible benefits if it prevents cavities and improves oral health [16].

Other critical components of the HBM are cues to action and self-efficacy. These can include external or internal triggers to take health related action, such as public health campaigns, responses of healthcare providers, personal experiences. Self-efficacy is how we feel that we can perform a certain behavior [17]. Significant improvements to change behavior have been demonstrated for both constructs [18, 19]. For example, the cues of community workshops on fluoride education and high self-efficacy in practice of good oral hygiene generate children to participate in dental programs.

It has wide applicability, yet important gaps exist to the understanding of HBM application to specific health education challenges in underserved populations. In the first case, existing studies revolve around individual level factors that do not examine how socio-cultural dynamics shape health beliefs. Second, research on HBM applications for children's health education, the focus of which is fluoride education, is limited. Third, the importance of self-efficacy is important but there is little research to inform how to enhance self-efficacy in resource poor settings via tailored interventions.

These gaps need to be addressed and this study uses the HBM to build a construct for fluoride education in underdeveloped regions using children as the target group. This research seeks to develop an effective and sustainable communication strategy to improve children's dental health outcomes by incorporating the six key constructs of the HBM and contextualizing them in socio-cultural settting.

3. Model and Hypotheses

3.1 Research Model

Starting from existing theoretical frameworks and empirical findings from the literature, we develop a research model to study how cultural adoption (Cul-Adop), cognitive engagement (CE), organizational health literacy (OHL) and key resource facilitation (KRF) interact. Additionally, the moderating role of environmental sustainability initiatives (ESI) and the mediating role of CE in examining CulAdop and ESI's relations to organizational outcomes are analyzed by the model. These relationships are shown in figure 1, in which the direct and indirect pathways are shown.

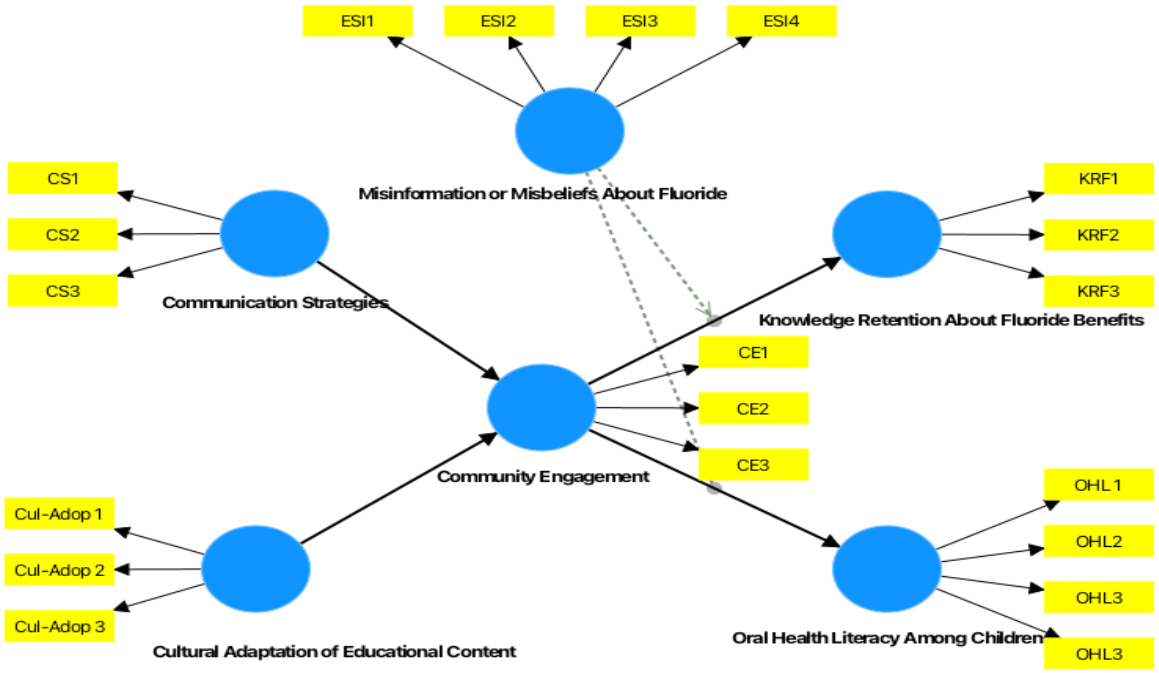

Figure 1: Research Framework

3.2 Cultural Adoption and Cognitive Engagement

Cultural adoption denotes the extent to which communities or organizations use culturally appropriate practices in their work. It includes incorporating use of practices, values and tools that are compatible with the cultural norms and as well as expectation of the target population. Previous research shows that engaging respondents with culturally aligned approaches is more likely because it makes it more relatable and impedes opposition to change [20]. Such misalignment is especially important in underserviced areas where it can thwart the efficacy of educational initiatives or tactics.

Cultural adoption then supplies the foundation to help individuals be cognitively engaged and actually 'process' and internalize the information. Accordingly, cultural symbols, languages or narratives used in educational materials can make learning more comprehendible and participative. In health promotion and organizational training programs, its demonstrated connection to engagement has been found in the alignment to culture. Therefore, we hypothesize:

H1: there is effects of the Cul-Adop on cognitive engagement (i.e., CE)

3.3. Organizing and Cognitive Engagement and Organizational Outcomes

Cognitive engagement implies active involvement when processing, understanding and utilizing of information. Higher engagement levels are a critical determinant of organizational success, as such levels often result in better resource utilization, and improved literacy outcomes. Other research suggests that individuals who are cognitively engaged are more likely to utilize resources best and to contribute towards an organizations or community health literacy [21]. An important connection between engagement is that people

who are engaged are more capable of allocating resources strategically and ensure their optimal use because people who are engaged are better prepared to facilitate key resource facilitation. Cognitive engagement also functions to support organizational health literacy (OHL) as people who are more cognitively engaged are more able to understand, spread, and apply health related knowledge. This relationship is critical to efforts like fluoride education because cognitive engagement in fluoride education translates knowledge to usable behavior. Thus, we propose:

H2: Key resource facilitation is facilitated by the cognitive engagement

H3: The relation of cognitive engagement on organizational health literacy is positive

3.4 Environmental sustainability initiatives as a moderator

Environmental sustainability initiatives (ESI) is the practice and strategies that are consistent with ecological and social goals. Adequate emphasis on these initiatives will transform the relationship between cognitive engagement and organizational outcomes by emphasizing shared purpose through shared responsibility. Implementation of ESI makes an organizational space in which people are practicing active participation and alignment with the broader sustainability goals. The alignment of cognitive engagement with initiatives that reflect the values of the individuals involved further increases the effect, as individuals become more motivated to join in and contribute. As an example, organizations can harness this via fluoride education contexts to optimize their participants' retention in resource facilitation and literacy efforts. ESI amplifies the effects cognitive engagement has on outcomes. Therefore, we hypothesize:

H4: ESI controls the relationship between cognitive engagement and key resource facilitation

H5: Cognition is moderated to moderate the relationship between cognitive engagement and organizational health literacy

3.5 The Enacting : Mediation by Cognitive Engagement

These mediation variables are input variables, including cultural adoption and environmental sustainability initiatives, to organizational outcomes through cognitive engagement. CE is a necessary mediator of outcome because it explains the relationship between culturally aligned practices and sustainability initiatives to measures such as improved resource facilitation and health literacy [22]. For example, cultural adoption represents a potential indirect pathway between cognitive engagement and key resource facilitation and health literacy. Likewise, ESI can help result in better outcomes by increasing peoples' engagement with knowledge and practices related to sustainability. Active participation, in achieving organizational goals, is underlined by cognitive engagement as a bridge between these constructs. Thus, we propose:

H6a: Key resource facilitation is mediated by cultural adoption affecting cognitive engagement

H6b: Cognitive engagement mediates cultural adoption's impact on organizational health literacy

H7a: Cognitive engagement mediates the effect of ESI in key resource facilitation.

H7b: Organizational health literacy is influenced by cognitive engagement

3.6 Interaction Effects

Environmental sustainability initiatives and cognitive engagement is more than that of additive effects. However, ESI and CE when interacting, create a synergistic effect in terms of transforming organizational outcomes. A second focus of this interaction centered on the alignment of sustainability goals and active engagement to maximise impact from initiatives [23]. For instance, individuals who are highly engaged are better prepared to take advantage of the opportunities afforded by a sustainability initiative and ultimately achieve increased levels of resource facilitation and literacy. Thus, the following hypotheses are proposed:

H8a: ESI as well as CE greatly enhances key resource facilitation

H8b: ESI has the interaction with robust CE

4. Methodology

4.1 Measures

Our research model consisted of five constructs: Cultural Adoption (CulAdop), Cognitive Engagement (CE), Environmental Sustainability Initiatives (ESI), Key Resource Facilitation (KRF) and Organizational Health Literacy (OHL). Three items were used to assess each construct. All items were adapted from existing scales to ensure content validity. All survey items are listed and their sources in table 1.

Cul-Adop items were adapted from Ferreira, Serra [20], and CE measures were derived from Fredricks, Blumenfeld [24]. Items adapted from Guthrie, Wigfield [25] were Environmental Sustainability Initiatives (ESI) items. Adapted from the work of Newton and Bower [26]. Key Resource Facilitation (KRF) and Organizational Health Literacy (OHL) were used. Items were measured on a five point Likert scale from 1 (strongly disagree) to 5 (strongly agree).

Table 1 describes the constructs and survey items with a view on how they were operationalized in this study. As control variables in the analysis, we included demographic variables: age, gender and years of experience in managing schools.

Table 1. Constructs and Survey Items

Construct	Item No	Survey Item	Source
Misinformation (ESI)	ESI1	I often encounter incorrect information about fluoride education on social media platforms.	[27]
	ESI2	There is a significant amount of misleading information regarding fluoride in our community communications.	
	ESI3	False claims about fluoride's benefits and risks are commonly shared among parents and teachers.	
	ESI4	I find it challenging to verify the accuracy of fluoride-related information available online.	
Oral Health Literacy (OHL)	OHL1	Our school provides comprehensive oral health education to students.	[28]
	OHL2	Students receive regular dental check-ups as part of our health programs.	
	OHL3	Our curriculum includes modules focused on the importance of fluoride for dental health.	
	OHL4	Parents are actively involved in supporting their children's oral health education.	
Communication Strategy (CS)	CS1	Our school effectively communicates the importance of fluoride education to parents and students.	[29]
	CS2	We utilize multiple channels (e.g., meetings, newsletters) to disseminate fluoride-related information.	
	CS3	The communication methods we use are tailored to meet the needs of our community.	
Cognitive Engagement (CE)	CE1	Staff members actively participate in developing fluoride education programs.	Newton and Bower [26]
	CE2	We engage in continuous learning to improve our understanding of fluoride-related health issues.	
	CE3	Our team collaborates effectively to enhance the effectiveness of fluoride education initiatives.	
Knowledge retention about fluoride Retention (KRF)	KRF1	Adequate resources are allocated for implementing fluoride education programs.	Fredricks, Blumenfeld [24]
	KRF2	We have access to the necessary tools and materials for effective fluoride education.	
	KRF3	Financial support is sufficient to sustain our fluoride education initiatives.	
	KRF4	Our school ensures timely procurement of resources needed for health education programs.	
Culture Adoption of educational content (Cul-Adop)	Cul-Adop1	The management understands the critical role of fluoride education in community health.	Ferreira, Serra [20]
	Cul-Adop2	Our organization effectively disseminates health information related to fluoride to stakeholders.	
	Cul-Adop3	We lead efforts to enhance the overall health literacy regarding fluoride in our community.	

	Cul-Adop4	Staff are well-informed about the latest research and guidelines on fluoride and oral health.	

4.2 Sample and Data Collection

Data were collected from the management staff of primary schools in Guizhou province, China, a province with relatively high fluoride concentration in water, but with its socio-economic development level lagging behind the country's average. 201 responses were received, which were retained after excluding incomplete questionnaires and responses with missing data leaving us with 167 valid responses.

The survey was conducted in three weeks in December of 2024. With the help of local collaborators, questionnaires were distributed in person to participants. A pilot study was conducted with 20 respondents prior to the survey to refine measurement items and improve the clarity. The pilot study provided feedback to help make the questionnaire contextually relevant and linguistically appropriate on a topic about which both the pilot and the writer were not experts.

The demographic makeup of the respondents is detailed in Table 2. Nearly 55% participants were male and their age between 35–44 years (41.3%). Half of respondents (50.9%) had 5-10 years' management of school experience and the majority of them (51.5%) regularly participated in health program initiatives. The demographic statistics presented here give an overview of the sample characteristics, presenting the range of experiences that the participants bring into the conversations.

Table 2. Demographic Characteristics of Respondents

Demographic Variable	**Category**	**Frequency (n)**	**Percentage (%)**
Gender	Male	92	55.1
	Female	75	44.9
Age	25–34 years	51	30.5
	35–44 years	69	41.3
	45–54 years	47	28.1
Experience in School Management	Less than 5 years	39	23.4
	5–10 years	86	51.5
	More than 10 years	42	25.1
Frequency of Health Program Involvement	Rarely	28	16.8
	Occasionally	54	32.3
	Regularly	85	50.9

5. Data Analysis and Results

We tested our research model in this study through structural equation modeling (SEM). To meet the suggestions of Anderson and Gerbing (1988), we first assessed reliability and validity by analyzing a measurement model. The structural model was then examined to test the research hypotheses. Data are analyzed using Smart PLS 3.0.1.

5.1 Measurement Model

5.1.1 Reliability and Validity

Reliability was tested on this study using Cronbach's α and composite reliabilities (CR). As can be seen in Table 2, all of the CR values are higher than 0.7, which means that values of all the CR and all the Cronbach's α are higher than 0.7, which means that the reliability of all constructs is good [30]. Convergent validity was also examined using standardized loading of items and the average variance extracted (AVE) of constructs. The convergent validity of all indicator loadings were greater than 0.70, all AVE were greater than 0.50, and thus satisfying the convergent validity [31].

Reliability and validity measures of each construct in the study are summarised in table 2. The reliability was tested using Cronbach's α and Composite Reliability (CR), which are used as important internal consistency measures of measurement scale. All Cronbach's α values are greater than the recommended value of 0.7, with the lowest, 0.874, for "Knowledge Retention About Fluoride Benefits" (KRF). This implies that the items in each construct measure essentially the same underlying concept. The CR values of the Composite Reliability (CR) are all above 0.7, the lowest CR is 0.882 in KRF, further validate the reliability of the constructs.

Average variance extracted (AVE) and standardized factor loadings were used to evaluate convergent validity. When above 0.5 an AVE clearly demonstrates that half (or more) of the variance of the indicators falls within the construct's domain, that is, they clearly exhibit good convergent validity. In Table 2, we see all the constructs have AVE values that exceed 0.5, with the lowest being 0.809 for KRF. Second, all standardized loadings exceed 0.70 indicating that each item positively influences its construct. Consider the "Misinformation or Misbeliefs About Fluoride" construct (ESI), for instance, which loads from high at .971 to high at .986 and we reinforce the strength of the measurement model.

Table 3 generally confirms that the measurement instruments used in this study are both reliable and valid within the criteria' set by [32, 33].This robust measurement model provides a solid platform on which to test structural model and subsequent hypothesis evaluations.

Table 3: Factor loadings

Vartiables		Items	Cronbach Aplha	CR	AVE
Communication Strategies	CS1	0.953	0.929	0.930	0.876
	CS2	0.917			
	CS3	0.939			
Community Engagement	CE1	0.981	0.977	0.978	0.957
	CE2	0.977			
	CE3	0.977			
Cultural Adaptation of Educational Content	Cul-Adop 1	0.984	0.971	0.987	0.945
	Cul-Adop 2	0.978			
	Cul-Adop 3	0.954			
Knowledge Retention About Fluoride Benefits	KRF1	0.925	0.882	0.885	0.809
	KRF2	0.899			
	KRF3	0.874			
Misinformation or Misbeliefs About Fluoride	ESI1	0.975	0.984	0.984	0.953
	ESI2	0.973			
	ESI3	0.986			
	ESI4	0.971			
Oral Health Literacy Among Children	OHL 1	0.957	0.956	0.958	0.883
	OHL2	0.943			
	OHL3	0.917			
	OHL3	0.941			

5.1.2 Common Method Bias (CMB)

The self reported and single sourced data in this study may be an indicator that CMB exists (Podsakoff et al., 2003). For this reason, CMB was evaluated using two approaches. Harman's first test — his one-factor test — was performed. The first factor explained only 38.44% of the total variance, less than 50% of the total variance. Second, we tested the data with the common latent factor approach for CMB [34].

To calculate the standardized regression weights for our study variables we carried out two confirmatory factor analyses with and without a common latent factor between the study variables. If the standardized regression weights of the two tests [35], do not differ significantly, we were unlikely to be affected by the CMB. The comparison of regression weights in Table 4, however, shows no dominant factor. As a result, these tests indicated that CMB was unlikely a big problem.

Table 4: Common Method Bias Assessment

Assessment Method	**Result**
Harman's One-Factor Test	Five factors were obtained, explaining 85.64% of the variance. The first factor accounted for 38.44% of the total variance, which is less than 50%.
Common Latent Factor Approach	No significant difference in the standardized regression weights was observed between models with and without the common latent factor, indicating that CMB was unlikely a significant problem.

In Table 4, we detail the assessment of Common Method Bias (CMB) for the study, which is especially important given the reliance of such data upon self reported, single source. One limitation of CMB is that it is capable of inflating or deflating the observed relationships between constructs, rendering the reliabilityof findings invalid. To mitigate this risk, two distinct methods were employed: Harman's one factor test and the Common Latent Factor (CLF) approach.

Harman's test of a one factor solution consists of exploring this through an exploratory factor analysis to see if the majority of the covariance between the measures can be explained by a single factor. The first test showed the extraction of five factors with total variance explained, 85.64%. Conveniently, the first factor explained only 38.44% of the total variance, which has not passed the critical 50%. Such analyses therefore suggest that no single factor dominates, so that CMB is not a pervasive issue in the data.

The second method, the Common Latent Factor approach, consists of adding a latent factor loading on all measured variables and compare the standardized regression weights with and without this factor. However, if CMB shows up if these significant differences are observed, it would be reported. Yet, as we can see from Table 5, the two models do not result in significant difference. This also strongly confirmed the absence of substantial CMB, as the standardized regression weights remained unchanged.

Combined results from both methods confirm that CMB plays only a minor role in the study's findings. This makes the measurement model more credible and ensures observed relationship between constructs is true and is not the artifact of methodological bias. As a result, it is more confident that its data analysis and subsequent interpretations are not compromised.

5.1.3 Discriminant Validity

If each correlation between any construct and any other construct (excluding ones measured with the same items) is less than the square root of AVE for that construct, then Fornell and Larcker (1981) argued that discriminant validity is achieved. The Heterotrait-Monotrait (HTMT) ratios for assessing some discriminant validity through another method are shown in table 5. Table 2

The Fornell and Larcker criterion is shown in Table 6, illustrating that for all constructs, the square roots of the AVEs for all constructs were greater than the corresponding correlations between the constructs. As a result, the good discriminant validity of the correlations shown by the study, is supported

Table 5: HTMT Ratios

	CS	CE	Cul-Adop	KFR	ESI	OHL
CS						
CE	0.496					
Cul-Adop	0.236	0.283				
KFR	0.471	0.591	0.383			
ESI	0.355	0.313	0.407	0.408		
OHL	0.445	0.427	0.475	0.504	0.446	

The Heterotrait-Monotrait (HTMT) ratios, a modern and reliable estimate of discriminant validity for structural equation modeling, are presented in Table 3. Discriminate validity is able to confirm that each construct is different and measures a different concept from other constructs within the model. The HTMT approach evaluates this ratio of between-trait correlations to within-trait correlations, and it is a strict test of discriminant validity [36].

All HTMT ratios in Table 3 are less than the conventional threshold of 0.90, thus implying that the constructs have been sufficiently separated. Take, for example, the maximum value of HTMT ratio, which is 0.591 between KFR and CE, far below the threshold. These low correlations imply minor overlap of these constructs such that they are lacking significantly unique function of the theoretical framework, as they measure unique aspects of the theoretical construct.

In addition, the HTMT ratios of all other pairs of constructs (e.g., "Communication strategies" vs "Oral health literacy among children" with an HTMT of 0.445) add strength to the measurement model's discriminant validity. Among these, the results provide confirmation that each construct measures unique dimensions and is free from redundancy, thereby improving the model's theoretical integrity.

In combination with the traditional Fornell and Larcker criterion, we find that the use of HTMT ratios adds a more nuanced view of discriminant validity. Instead, the HTMT method measures the overlap between constructs directly, and so is a more sensitive one. This reinforces the

conclusion that the measurement model has robust discriminant validity as evident in Table 3 and Table 5, as both methods produce consistency of results.

Table 6: Fornell and Larker criterian

	CS	CE	Cul-Adop	KFR	ESI	OHL
CS	0.936					
CE	0.473	0.978				
Cul-Adop	0.224	0.278	0.972			
KFR	0.426	0.550	0.356	0.900		
ESI	0.339	0.307	0.399	0.380	0.976	
OHL	0.421	0.414	0.459	0.464	0.434	0.940

The measurement model can be assessed for discriminant validity with Fornell and Larcker criterion, which is shown in table 6. A circumstance in which discriminant validity is established by the fact that the AVE from each construct is stronger than its highest correlation with any other construct in the model is according to Ab Hamid, Sami [37] , when the square root of AVEs are more than the correlations. This enables the distinctiveness of each construct to be confirmed by ensuring that more variance of each construct is shared with its own indicators than any other construct.

As can be seen in Table 6, in the diagonal elements of the Table, the AVE that is represented by the square root. Just as an example, the square root of AVE for CS ("Communication Strategies") is 0.936, and higher than correlations with any other construct. Just likeCommunity Engagement,' or CE, has a square root AVE of 0.978, more than its correlations with other constructs. This pattern is seen with each construct, implying that all inter construct correlation of the constructs is less than AVE of the construct.

All of the inter construct correlations presented in the lower diagonal part of Table 6 are less than the square root of AVE. For instance, in Cul-Adop vs. KFR, their correlation is 0.356, which is less than square root AVE for Cul-Adop (0.972) and KFR (0.900). They are distinct and do not overlap much, which means this.

Moreover, the agreement of HTMT ratios present in Table 3 with the Fornell and Larcker criterion highlights the robustness of the discriminant validity assessment. Both approaches converge on the conclusion that the constructs are well differentiated, thus multiple layers of validation for the measurement model. Finally, summarized in Table 4, the results indicate that the constructs in the measurement model have good discriminant validity according to the Fornell and Larcker criterion. Thus, this also increases the overall validity of the measurement model and guarantees that constructs are not measuring one same theoretical concept, which in turn, helps to have integrity in the structural model and the study's hypotheses.

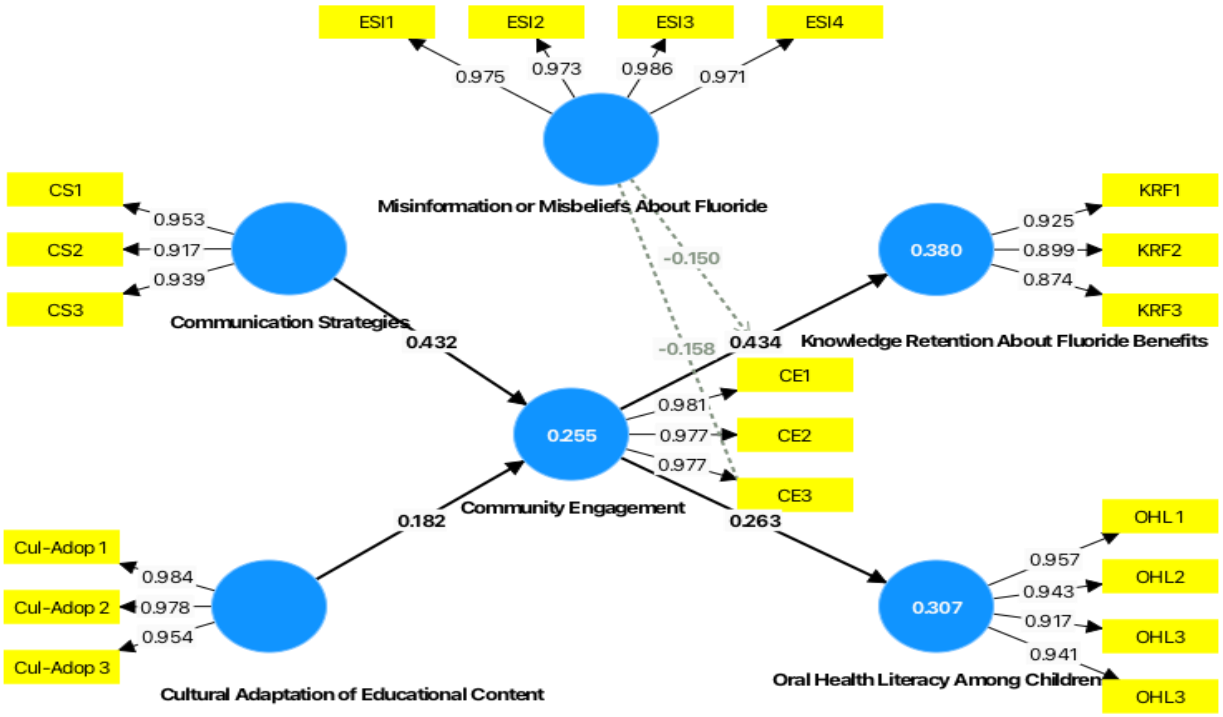

Figure 2: Measurement Model

5.2 Structural Model

Parameters were estimated using a maximum likelihood estimation technique. The model fit indices are specified as follows: Evidence of a good model fit was based on $\chi 2/df = 1.805$, RMR = 0.036, GFI = 0.907, NFI = 0.929, RFI = 0.914, IFI = 0.967, TLI = 0.960, CFI = 0.967, RMSEA = 0.056 (Bagozzi et al., 1991). In sum, these indices together indicate that the estimated model in good agreement with observed data, satisfying the commonly accepted thresholds for each fit measure. In particular, $\chi^2/df < 3$ is acceptable. The RMSEA value of 0.056 is within agreement with the rate of good fit ($\leq$ 0.06). Additionally, CFI and TLI of the model exceed 0.95 level, which confirms the adequacy of model fit. These fit indices are summarized in table 7, which indicates the robustness of the structural model.

Table 7: Model Fit Summary

	Saturated model	Estimated model
SRMR	0.028	0.079
d_ULS	0.170	1.319
d_G	0.278	0.296
Chi-square	3293.555	3256.703
NFI	0.934	0.935

The Model Fit Summary, including more fit indices to determine how well estimated structural model fits observed data, is presented in Table 7. In SEM, the model fit needs to be assessed as it includes adequacy of the proposed model in depiction of the latent data structure. The table compares two models: Saturated Model and the Estimated Model.

The standardised Root Mean Square Residual on the Saturated Model is 0.028 and they are 0.079

for the Estimated Model. Fits of this sort are considered good when values of SRMR smaller than 0.08 are found. For the Saturated Model, the d_ULS values are 0.170; for the Estimated Model, they are 1.319. Model 2 estimates a value of d_ULS closer to 1 and significant reduction of d_ULS from both Saturated to Estimated Model. The d_G (Geodesic Distance) is used to measure discrepancy between the sample covariance matrix and the model implied covariance matrix. The Saturated Model values a 0.278 and the Estimated Model 0.296 values indicate that the Estimated Model still fits as appropriately. The Chi-square values for the Saturated Model and the Estimted Model are 3293.555 and 3256.703 respectively. Chi square is sensitive to sample size and is often significant in large samples; however the ratio of $\chi^2/df = 1.805$ (from text) is within acceptable range (less than or equal to 3) of which implies good fit. Finally, NFI (Normed Fit Index) values are 0.934 for Saturated Model and 0.935 for Estimated Model. With values of NFI above 0.90, a good fit is indicated, and the slight improvement in the Estimated Model confirms its adequacy.

Overall, fitting the data according to the Estimated Model is shown in Table 4 to be relatively good as per several fit indices. Together, the SRMR, d_ULS, d_G, Chi-square and NFI values collectively validate and confirm the strength and validity of the structural model, which affords a means of interpretation of the results of subsequent tables, in which path coefficients and indirect effects are exhibited.

Path coefficient Analysis

The Path Coefficients for the hypothesized relationships contained within the structural model are listed in Table 5. The coefficients indicate the strength and direction of these relationship in each path. The path itself is a direct relationship between constructs.

The coefficient with respect to the path from Communication Strategies (CS) to Community Engagement (CE) is 0.432 and is statistically significant at p<.001 and also substantial in magnitude. This means that community engagement is significantly improved by effective communication strategies. Also, CE -> KRF (0.434) and CE -> OHL (0.263) are found to have positive and significant relationships, implying that enhanced community engagement will enhance knowledge retention related to fluoride benefits (KRF) and increase oral health literacy of children (OHL).

All three paths, from CE -> CEC, from Cul-Adop -> CEC, and from Cul-Adop -> CE have coefficients that are significant, with coefficient of 0.182 for path Cultural Adaptation of Educational Content (Cul-Adop) -> CE, supporting the claim that educating more culturally improves community engagement. That is in keeping with the idea that culturally relevant materials tend to be more successful in engaging diverse communities.

As a coefficient of 0.223, Misinformation or Misbeliefs About Fluoride (ESI) -> KRF path means, if we address positively misinformation related to misleading fluorides, it would influence KRF. ESI -> OHL also has a higher coefficient of 0.328 which indicates more likely effect in oral health literacy. Both negative and significant ($p<0.05$) interaction terms include ESI x CE -> KRF (-0.150) and ESI x CE -> OHL (-0.158), respectively, suggesting that misinformation combined with community engagement negatively affect KRF and OHL. This may imply that high community engagement cannot protect against misinformation so as to retain knowledge and maintain literacy.

These relationships are all statistically significant given that all paths have high T statistics (from 7.724 to 20.666) and P values of 0.000. These path coefficients have significant and strong power in supporting the hypothesized relationships, soempirical testing of this theoretical framework. As a whole, Table 8 emphasizes the leading role of strategies for communication and involving the community in order to improve the learning of knowledge and oral health literacy. It also shows the malign effects of misinformation (even in spite of a lot of community engagement). Insights such as these are essential to developing the kind of interventions that can improve oral health outcomes through engaged and informed communities.

Table 8:Path coefficients

	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values
CS-> CE	0.432	0.432	0.021	20.666	0.000
CE -> KRF	0.434	0.434	0.021	20.474	0.000
CE -> OHL	0.263	0.262	0.023	11.451	0.000
Cul-Adop -> CE	0.182	0.182	0.020	9.169	0.000
ESI -> KRF	0.223	0.223	0.024	9.225	0.000
ESI -> OHL	0.328	0.329	0.029	11.298	0.000
ESI x CE -> KRF	-0.150	-0.149	0.017	8.617	0.000
ESI x CE -> OHL	-0.158	-0.158	0.020	7.724	0.000

Specific Indirect Effect relationship

Specific Indirect Effect relationship between two constructs through intermediary variables can be found in table six below and it demonstrates that some constructs influence others. However, understanding of such indirect effects is crucial in making sense of how independent variables operate to produce responses in dependent variables. Original sample value of 0.187, and sample mean of 0.188 are the 1st indirect path CS -> CE -> KRF. If this is true this would mean that Communication Strategies (CS) leads to an increase in Community Engagement (CE), which, in turn, causes an increase in Knowledge Retention About Fluoride Benefits (KRF). This path showed that effective communication is related to more community involvement which in turn is related to more improvement of knowledge retention ($p < 0.001$). Just as, CS -> CE -> OHL the path with an original sample value of 0.114 implies that Communication Strategies (CS) influence Oral Health Literacy Among Children (OHL) through Community Engagement. This positive indirect effect is an indication of the contribution of communication

to making oral health literacy a success through effective community engagement.

Analysis of this indirect effect Cul-Adop -> CE -> KRF (0.079) shows that Cultural Adaption of Education Content (Cul-Adop) has a positive effect on Knowledge Retention through Community Engagement. Although comparatively small in magnitude, the coefficient is significant ($p < 0.001$), indicating that culturally geared educational material is essential to sustain retention of knowledge within engaged communities. Finally, the generated sample value of Cul-Adop -> CE -> OHL for original model is 0.048 which indicates a negative but smaller indirect effect on Oral Health Literacy. Even small, the significance of this path ($p < 0.001$) indicates cultural adaptation makes a capability to improve on oral health literacy by increased community engagement. These mediating relationships are robust and reliable as all indirect paths in Table 6 have high T statistics and are statistically significant ($p < 0.001$). These findings provide empirical support that the hypothesized mediation effects hold for Communication Strategies, Cultural Adaptation, Community Engagement and the outcomes of Knowledge Retention and Oral Health Literacy.

Table 9:Specific indirect effects

	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values
CS -> CE -> KRF	0.187	0.188	0.014	13.566	0.000
CS -> CE -> OHL	0.114	0.114	0.012	9.437	0.000
Cul-Adop -> CE -> KRF	0.079	0.079	0.010	8.158	0.000
Cul-Adop -> CE -> OHL	0.048	0.048	0.007	6.446	0.000

To sum, Table 9 presents the complex communications and cultural adaptation strategies that key area outcomes are influenced by. In particular, the table points out the mediating role of community engagement, highlighting the multiplicity of factors that should be taken into consideration in making sense of effective health communication and education strategies. But these insights are also invaluable to practitioners and policymakers looking to design interventions that not only engage communities — but that do so to ultimately drive meaningful health outcomes.

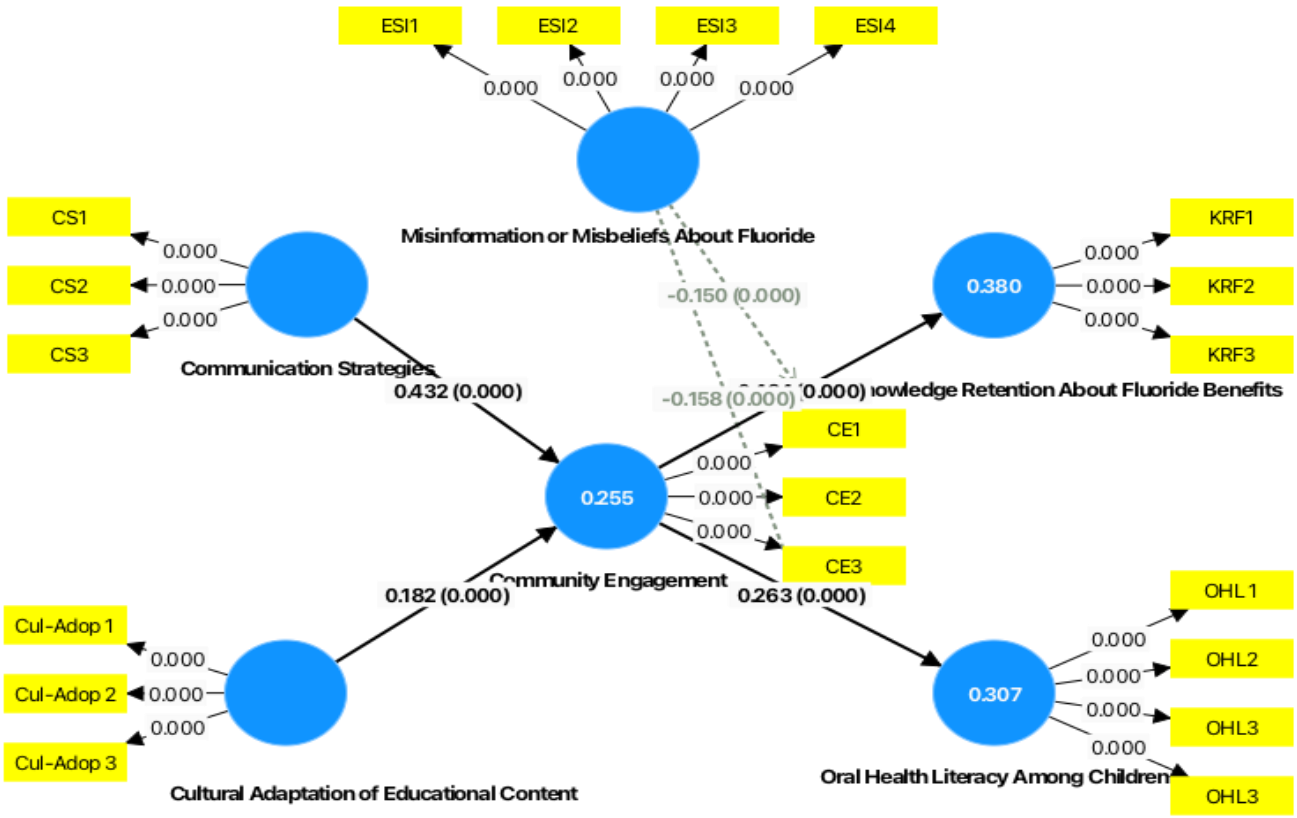

Figure 3: Structural Model

6. Discussion

6.1 Findings

The findings of the present study have valuable implications to the understanding of the relationships of communication strategies to community engagement, cultural adaptation, misinformation, knowledge retention, and oral health literacy in children. Results of the first analysis is that CS are positively related to CE as clearly suggested by a significant path coefficient of 0.432 (Table 5). This is an important finding that recognises the important role communication plays in creating community engagement. Possibly, health related messages become clearer, pertinent and appealing through use of effective communication strategies which in turn will attract community members to participate and interact.

Second, the magnitude of the positive relationship of Community Engagement (CE) with both Knowledge Retention about Fluoride benefits (KRF) and Oral Health Literacy among Children (OHL) is substantial (path coefficients: 0.434 for KRF and 0.263 for OHL) (Table 5). The implication from these results is that engaged communities are more effective in disseminating and reinforcing knowledge of fluoride benefits leading to increased children's oral health literacy. This same emphasis on community involvement in health education and participation in health behavior change corresponds with previous literature [38].

The third finding of significant path coefficient to Community Engagement (CE) (0.182) from

the Cultural Adaptation of Educational Content (Cul-Adop) (Table 5) supports these arguments. The implication suggests that educational materials can be better tailored to adhere to the cultural contexts to which the target population is known [39]. Content adapted for the socio-cultural setting is more relatable and acceptable against which community members are more likely to be active participants and retain details.

Finally, negativily impacting both Knowledge Retention (KRF) and Oral Health Literacy (OHL) by path coefficients 0.223, 0.328 (Table 9) Misinformation or Misbeliefs about Fluoride (ESI). This points out the destructive effect of misinformation in public health education. Prevention of the spread of misinformation and managing the same effectively are important for dissemination of the treatment plan to the target population and validating its relevance. ESI x CE negatively affect both KRF and OHL with coefficients of -0.150 and -0.158 respectively (Table 5). This interaction highlights that even in high engagements communities, misinformation can frustrate knowledge retention and oral health literacy. Instead, this study highlights the need for strong countermeasures geared against misinformation in engaged communities to foster and maintain educational outcomes.

Finally, there is lot indirect influence presented in table 6; which shows that Communication Strategies and Cultural Adaptation indirectly affect KRF and OHL through Community engagement. The presence of these indirect paths (such as CS-->CE--> KRF) confirm the mediating position of community engagement on the link between communication efforts and educational outcomes. Taken together, these results provide support for strategic communication and cultural adaptation as critical factors that can facilitate community engagement leading to increase of oral health literacy and knowledge retention. This also points to the need to aim for targeted interventions to ensure that health education initiatives remain undistorted by misinformation.

6.2 Theoretical Implications

This study yields several important theoretical implications. Second, this research goes on to extend existing health communication literature by providing insight concerning the mediating role of Community Engagement acting as a mediator between Communication Strategies (CS), Cultural Adaptation (Cul-Adop) and preschoolers' educational outcome (KRF and OHL). Although previous studies have recognized direct effects of communication and cultural factors on health outcomes, this study adds to the burgeoning literature by demonstrating the critical mediating role of the community engagement dimension of the C–A–C (Cognition-Affect-Conation) framework.

Second, the study contributes to our understanding of the C–A–C framework by centering Misinformation or Misbeliefs About Fluoride (ESI) as a cognitive factor modulating ESI with community engagement as a causal mechanism to alter educational outcomes. With this integration we are able to provide a more nuanced picture about how misinformation can impede the positive effects of community engagement shaping knowledge retention and literacy. The results suggest that communication and cultural adaptation strategies must address cognitive barriers to optimally perform such as misinformation.

Third, this study enriches the emotion based literature in health communication by focusing on diminishment of misinformation in communities that are involved. This reaffirms the need to tackle the antecedents to negative cognitive factors to protect from any associated adverse effect on affective and behavioral outcomes. This is in line with theories of information processing and emotion regulation

which hold that cognitive distortions have large effects on emotional and behavioral responses.

The development and validation of a context specific scale for Information Avoidance Intention for the area of oral health education represents a methodological development. This measurement allows us to quantify information avoidance in a manner that is tailored to understand the unique dimensions of information avoidance in social media contexts, which could serve as a valuable research tool in many such settings.

Theoretical contributions of this study are in its refined use of C-A-C framework, its integration of misinformation as a key cognitive factor, and its contribution to measurement innovations of information avoidance. This contributes significant ground to be built upon by future research and the intersection between communication strategies, culture, misinformation and health education outcomes.

6.3 Practical Implications

The practical implications for health educators, community organizers, and policymakers wishing to promote oral health literacy and knowledge retention in children are many and neither good nor bad. First, that CS have a positive impact on CE implies that, health educators should invest in developing effective communication tools and techniques. It incorporates the usage of the clear and concise communication that articulates well normal information and focusing on the interests and needs of the consumer audience. Educators can improve communication effectiveness which in turn will improve the levels of community engagement, and ultimately higher educational outcomes.

Second, the importance of Cultural Adaptation of Educational Content (Cul–Adop) in promoting Community Engagement (CE) is notably important as culturally sensitive health education materials are essential. Educational content must not only be accurate but culture relevant and respectful to the practitioners. I believe this could be accomplished by engaging the community in the development of educational programs, and by including culturally suitable symbols, language and examples.

Third, the harmful consequences of Misinformation or Misbeliefs About Fluoride (ESI) on Knowledge Retention (KRF) and Oral Health Literacy (OHL) underscore the need to develop anti-misinformation strategies. Proactive measures such as fact checking by health educators and community leaders, providing evidence based information, as well as the creation of platforms for open dialogue about fluoride benefits are needed to dispel and address myths about fluoride. The fourth is that the interaction between ESI and CE indicates that in very engaged communities, misinformation can have a substantial deleterious effect on educational efforts. As such, community engagement strategies must be founded on continuous monitoring and countering of misinformation. It could be as simple as training community leaders to spot misinformation and deprogram it, or the more involved of bringing trusted community voices into reinforcing accurate information.

The fifth indirect effects of Communication Strategies and Cultural Adaptation through Community engagement indicates that engagement can be a viable pathway to improvement of educational outcomes. Rather than focusing on how many people participate in health education and promoting various health behavior change campaigns, practitioners should aim to create strong, interactive communities

where folks feel they are important and want to participate in health education activities. The study ends by saying that comprehensive educational approaches which incorporate effective communication, cultural sensitivity and how to deal with misinformation are vitally important. However, if health educators adopts such multifaceted strategies the communities become more resilient and informed, this has the potential of improving oral health outcomes among children. The practical implications of this study recommend a strategic communication, cultural adaptation, proactive misinformation management and robust community engagement as key components of effective oral health education programs.

6.Future Research

4 Limitations

Although this study is important it is not without its limitations, and some things need to be addressed in future research. Second, the sample is mostly made up of university students, which may make the findings not generalizable to more populations. Future directions will involve a more diverse demographic to determine whether the observed relationships apply to disparate ages, educational levels, and socioeconomic statuses.

In addition, the study was performed within the bounds of a specific social media platform, and may constrain the generalizability of results to other social media platforms characterized by different set of features and user dynamics. The social media environment (Facebook, Instagram, Twitter) in which a post lives may effect community engagement and the spread of misinformation differently. Future work should explore these relationships in different platforms to achieve generalizability of the results.

Third, the model presents a limited set of antecedents and outcomes. In particular, only one cognitive factor (ESI) and two affective outcomes (KRF and OHL) were examined. Future studies could include additional cognitive (such as perceived information quality), affective (such as anxiety, trust) and social (such as peer influence, subjective norms) factors to better understand determinants and consequences of community engagement and knowledge retention. The fourth problem is that the study is based on self reported data, which may be subject to biases from social desirability or from recall bias. Future research incorporating objective measures or longitudinal designs could reduce these biases and offer more robust evidence of causal relationships. Fifth, although the study created a context specific scale for the Information Avoidance Intention, it does not distinguish short term from long term avoidance behavior. The definition of information avoidance may have to be refined in further research, perhaps to differentiate transient disengagement from sustained avoidance.

Finally, the study controlled for a set of limited demographic and behavioural variables (i.e. age, gender, use experience, frequency). Future studies could add other control variables such as education, income and technological knowledge which might otherwise alter the observed relationships. Overall, tackling these limitations in future work will bolster the applier of these findings and thus increase the sensitivity and band-width of the findings as well as a more thorough understanding of the relationships between cultural factors, communication strategies, misinformation, and health education outcomes.

7. Conclusion

The purpose of this study was to examine the influence of Community Engagement (CE) by Communication Strategies (CS) and Cultural Adaptation of Educational Content (Cul-Adop)

on Knowledge Retention About Fluoride Benefits (KRF) and Oral Health Literacy Among Children (OHL). In addition it looked at the role of Misinformation or Misbeliefs About Fluoride (ESI) and how the two interacted with community engagement in relationship to these educational outcomes.

The results provide support for the proposed research model, and it is shown that communication strategies will be effective and culturally adapted educational content will significantly enhance community engagement. It also means that better levels of community engagement translates to better knowledge retention and oral health literacy in children. Although there is misinformation, it hurts these outcomes in engaged communities as well, making the need for strategies to combat misinformation all the more important.

Taken together it was found that the benefits of communication and cultural adaptation efforts are undercut by perceived misinformation, and therefore efforts aimed at combating misinformation must be placed higher on the priority list for its effects to be fully harnessed by health education initiatives. The study yet again points at the need to adopt strategic communication, cultural sensitivity, and proactive misinformation management to develop health literate and informed communities.

In sum, this research advances the health communication knowledge by revealing how communication and cultural elements contribute to educational outcomes by also enhancing how misinformation affects education. The practical implications of these insights for designing effective health education programs, and the groundwork on which subsequent study can build to better understand and extend these associations, are offered.

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