International Journal of Medical and Health Research
ISSN: 3078-4824
DOI: 10.61424/ijmhr
Journal Homepage: www.bluemarkpublishers.com/index.php/IJMHR

IJMHR
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| RESEARCH ARTICLE

Evaluating the Impact of Community-Based Oral Health Education Programs on Preventive Dental Behaviors among Adults in the United States

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| ABSTRACT

Poor oral health remains a significant public health challenge in the United States, with preventable dental diseases disproportionately affecting vulnerable populations despite widespread availability of effective preventive practices. This study evaluates the effectiveness of community-based oral health education programs in modifying preventive dental behaviors among adults across diverse socioeconomic and geographic contexts. Using a quasi-experimental design with matched comparison groups, this research assessed 1,847 adult participants (ages 18-75) across 12 community-based intervention sites in six states, measuring changes in brushing frequency, flossing habits, dietary behaviors, and dental visit patterns over a 12-month period. Intervention modalities included in-person community workshops (n=624 participants), digital awareness campaigns via social media and mobile applications (n=618), and hybrid approaches combining multiple delivery methods (n=605). Data collection employed validated self-report instruments, clinical oral health assessments, and dental utilization records. Results demonstrate that community-based education programs produced statistically significant improvements in multiple preventive behaviors: twice-daily brushing increased from 58.3% at baseline to 76.8% at 12-month follow-up ($p<0.001$), daily flossing increased from 31.2% to 52.4% ($p<0.001$), sugary beverage consumption decreased by 34% ($p<0.001$), and biannual dental visits increased from 42.6% to 61.3% ($p<0.001$). Hybrid intervention approaches demonstrated superior outcomes compared to single-modality programs across all measured behaviors. Effect sizes were moderated by participant demographics, with larger improvements observed among younger adults (18-35 years), higher-educated individuals, and those with dental insurance coverage. Clinical assessments revealed corresponding improvements in periodontal health indicators including reduced plaque scores (Cohen's $d=0.52$) and decreased gingival inflammation ($d=0.48$). Economic analysis indicated a favorable cost-effectiveness ratio of $87 per participant achieving sustained behavior change, substantially lower than treatment costs for preventable dental conditions. This research provides robust evidence that well-designed community-based oral health education programs effectively modify adult preventive behaviors, with implications for public health programming, resource allocation, and policy development aimed at reducing oral disease burden and health disparities.

| KEYWORDS

Oral health education, community health programs, preventive dental behaviors, health behavior change, dental hygiene, health literacy, public health intervention, behavior modification, dental care utilization, health disparities

| ARTICLE INFORMATION

ACCEPTED: 21 July 2023 **PUBLISHED:** 17 September 2023 **DOI:** 10.61424/ijmhr.v1.i1.605

1. Introduction

Oral health represents a critical yet often overlooked component of overall health and well-being, with profound implications for nutritional status, chronic disease management, psychological health, and quality of life (Peres et al., 2019). Despite remarkable advances in dental science and widespread availability of effective preventive measures, oral diseases remain among the most prevalent chronic conditions globally, affecting nearly 3.5 billion people worldwide and representing a substantial public health burden (Kassebaum et al., 2017). In the United States specifically, dental caries (tooth decay) affects approximately 91% of adults aged 20-64, while severe periodontal disease affects 42% of adults over 30 years of age, with disproportionate burden among

low-income populations, racial and ethnic minorities, and rural residents (Centers for Disease Control and Prevention [CDC], 2021).

The paradox of contemporary oral health is striking: while the knowledge, tools, and techniques necessary to prevent most oral diseases are well-established and widely accessible, behavioral uptake of these preventive practices remains disappointingly low across many population segments (Tonetti et al., 2017). Simple, low-cost behaviors including twice-daily tooth brushing with fluoride toothpaste, daily interdental cleaning, limiting sugar consumption, and attending routine dental examinations can prevent or substantially mitigate most oral diseases, yet adherence to these practices varies considerably across demographic groups and geographic regions (Kirscht et al., 2020).

Multiple barriers impede optimal oral health behaviors among U.S. adults. Financial constraints represent a primary obstacle, as dental insurance coverage remains substantially less comprehensive than medical insurance, with approximately 74 million Americans lacking any dental insurance coverage and many more possessing coverage with significant limitations (Nasseh & Vujicic, 2021). Even among insured populations, high deductibles, copayments, and coverage exclusions create financial disincentives to routine preventive care. Geographic access barriers are particularly acute in rural areas and urban dental deserts where dental provider shortages limit access to professional services, though geographic barriers affect preventive self-care behaviors less directly than professional care utilization (Vujicic & Nasseh, 2014).

Beyond structural barriers, knowledge deficits and health literacy limitations contribute substantially to suboptimal preventive behaviors. Many adults possess incomplete or inaccurate understanding of proper oral hygiene techniques, the causal relationship between dietary choices and oral disease, or the importance of preventive dental visits even in the absence of symptoms (Horowitz et al., 2013). Health literacy the ability to obtain, process, and understand basic health information needed to make appropriate health decisions significantly predicts oral health behaviors and outcomes, with lower health literacy associated with poorer oral hygiene practices and increased disease burden (Jones et al., 2016).

Cultural factors, beliefs, and health-related attitudes also influence preventive dental behaviors. In some cultural contexts, dental care is perceived as necessary only when pain or dysfunction occurs, rather than as an ongoing preventive practice (Jamieson & Thomson, 2020). Dental anxiety and fear, affecting an estimated 36% of the U.S. adult population to some degree, create psychological barriers to both professional dental care and consistent home oral hygiene practices (Slade, 2013). Additionally, competing priorities in the context of limited time and resources lead many adults to deprioritize oral health relative to other health concerns or life demands.

Community-based health education programs represent a promising approach to addressing knowledge gaps, modifying health beliefs, building skills, and ultimately changing behaviors (Glanz & Bishop, 2010). Unlike clinical interventions delivered in healthcare settings to individuals seeking care, community-based programs reach populations where they live, work, and socialize, potentially engaging individuals who might not otherwise access health information or services. Community settings including schools, workplaces, faith-based organizations, community centers, and online communities provide opportunities for repeated exposure, social reinforcement, and normalization of healthy behaviors.

The theoretical foundation for community-based health education draws from multiple behavior change frameworks. The Health Belief Model posits that health behaviors are influenced by perceived susceptibility to health conditions, perceived severity of conditions, perceived benefits of preventive actions, perceived barriers to action, cues to action, and self-efficacy (Rosenstock et al., 2015). Social Cognitive Theory emphasizes reciprocal interactions among personal factors, environmental influences, and behavior, highlighting the importance of observational learning, self-efficacy, and outcome expectations (Bandura, 2018). The Theory of Planned Behavior suggests that behavioral intentions influenced by attitudes toward the behavior, subjective norms, and perceived behavioral control predict actual behavior (Ajzen, 2015). Effective community-based programs typically incorporate principles from multiple theoretical frameworks, using varied strategies to address cognitive, affective, social, and environmental determinants of behavior.

Contemporary community-based oral health education programs increasingly leverage diverse delivery modalities. Traditional in-person workshops and seminars provide opportunities for interactive learning, skill demonstration, and personal engagement with health educators. Digital health interventions utilizing websites, mobile applications, social media platforms, and text messaging enable broad reach, personalized content delivery, and convenient access fitting diverse schedules and preferences (Naslund et al., 2017). Hybrid approaches combining in-person and digital components may harness advantages of both modalities while addressing their respective limitations.

Despite widespread implementation of community-based oral health education programs, rigorous evaluation of their effectiveness in changing adult preventive behaviors remains limited. Much existing research focuses on children and adolescents, often in school settings, while adult populations receive comparatively less attention despite comprising the majority of individuals with established oral disease and behavioral patterns (Watt et al., 2019). Studies examining adult oral health education frequently suffer from methodological limitations including small sample sizes, lack of comparison groups, short follow-up periods insufficient to assess sustained behavior change, reliance solely on self-reported behaviors without objective verification, and failure to account for confounding variables (Csikar et al., 2019). Additionally, few studies systematically compare different educational delivery modalities or examine how participant characteristics moderate intervention effects.

This research addresses these gaps by conducting a comprehensive, methodologically rigorous evaluation of community-based oral health education programs targeting adults across diverse socioeconomic and geographic contexts in the United States. The study assesses three primary research questions: (1) Do community-based oral health education programs produce measurable, sustained changes in preventive dental behaviors among adult participants? (2) How do different program delivery modalities (in-person workshops, digital campaigns, hybrid approaches) compare in effectiveness? (3) What participant characteristics moderate intervention effectiveness, and how can programs be optimized for diverse populations?

1.2. Significance of the Study

This research holds substantial significance for multiple stakeholder groups within the oral health ecosystem and contributes to both scientific knowledge and practical public health programming.

For Public Health Practitioners and Program Planners

Public health departments, nonprofit organizations, and community health centers invest considerable resources in oral health education programs, yet often lack robust evidence regarding which program components and delivery modalities produce optimal outcomes for diverse adult populations. This study provides actionable, evidence-based guidance for program design and resource allocation. The comparative evaluation of in-person, digital, and hybrid approaches enables practitioners to make informed decisions about program delivery methods suited to their target populations, available resources, and community contexts. The identification of participant characteristics that moderate intervention effectiveness allows for program tailoring and targeted outreach to populations most likely to benefit.

The demonstrated cost-effectiveness of community-based education $87 per participant achieving sustained behavior change provides compelling economic justification for program investment. Preventive oral health education represents a cost-effective alternative to treating advanced dental disease, with potential for substantial healthcare cost savings when implemented at scale (Griffin et al., 2014). The economic evidence can support funding applications, budget justifications, and advocacy for sustained program support.

For Healthcare Providers and Dental Professionals

Dentists, dental hygienists, and other oral health professionals play crucial roles in patient education during clinical encounters, yet clinical visit time constraints limit the depth and breadth of education possible. Community-based programs complement clinical education by providing more extensive, reinforced messaging in accessible community settings. Understanding the effectiveness of community education enables dental professionals to support and promote these programs, refer patients to community resources, and potentially partner with community organizations to extend educational reach.

The study's findings regarding which behaviors prove most amenable to change through community education can help dental professionals prioritize clinical education topics and tailor recommendations to individual patient contexts. For behaviors resistant to change through community education alone, dental professionals may need to employ additional motivational interviewing techniques, personalized counseling, or clinical interventions.

For Policy Makers and Health System Leaders

Health policy decisions regarding public health funding, Medicaid dental benefits, insurance coverage requirements, and health promotion initiatives require evidence of program effectiveness and cost-effectiveness. This research provides policy-relevant evidence regarding returns on investment in preventive oral health education, with implications for resource allocation across prevention versus treatment services. The demonstration that relatively modest educational investments can produce meaningful behavior change supports policy emphasis on prevention and early intervention rather than exclusively treatment-focused approaches.

The identification of health disparities in intervention effectiveness has important equity implications. Policy makers can use these findings to design programs specifically addressing the needs of populations experiencing poorer outcomes, ensuring that public health investments reduce rather than inadvertently exacerbate existing disparities. Additionally, evidence regarding digital intervention effectiveness informs policy discussions about broadband access, digital literacy, and technology as a mechanism for health promotion.

Academic and Theoretical Contributions

From a scientific perspective, this research advances understanding of health behavior change processes and the effectiveness of community-based interventions. The study's rigorous quasi-experimental design with 12-month follow-up, combined sample of self-reported and clinically assessed outcomes, and analysis of moderating factors provides methodological rigor often lacking in community-based oral health education research. The findings contribute to behavior change theory by identifying which theoretical constructs and intervention strategies prove most effective for oral health behaviors among adults.

The comparative evaluation of delivery modalities addresses important questions about the role of technology in health education. As digital health interventions proliferate, understanding their effectiveness relative to traditional in-person approaches and how these modalities can be optimally combined represents an important scientific contribution applicable beyond oral health to other health behavior domains.

Societal Impact and Health Equity

Ultimately, the significance of this research extends to broader societal objectives around health equity, quality of life, and healthcare cost containment. Oral health significantly affects overall health, with established links between periodontal disease and systemic conditions including diabetes, cardiovascular disease, and adverse pregnancy outcomes (Linden et al., 2013). Poor oral health also affects nutritional status, particularly among older adults, and imposes substantial quality of life burdens including pain, difficulty eating, speech problems, and social embarrassment affecting employment and relationships.

Oral health disparities represent a persistent inequity, with low-income populations, racial and ethnic minorities, and rural residents experiencing substantially higher rates of untreated dental disease and tooth loss (Vujicic & Nasseh, 2014). Effective community-based education programs accessible to vulnerable populations represent one tool for reducing these disparities. To the extent that this research identifies effective, scalable approaches to improving preventive behaviors across diverse populations, it contributes to health equity objectives.

1.3 Problem Statement

Despite widespread recognition of oral health's importance and the availability of effective preventive measures, a substantial proportion of U.S. adults engage in suboptimal preventive dental behaviors, resulting in high rates of preventable oral disease, associated health complications, substantial economic burden, and persistent health disparities (Peres et al., 2019). This problem manifests across multiple dimensions requiring urgent attention.

Behavioral Inadequacy and Knowledge Gaps

National surveillance data reveal concerning patterns of preventive behavior inadequacy among U.S. adults. Only approximately 58% of adults report brushing their teeth twice daily, the minimum frequency recommended by dental professionals, while daily flossing is practiced by only 30-35% of adults despite universal professional recommendations for daily interdental cleaning (American Dental Association [ADA], 2020). Routine dental visits for preventive care occur biennially for only about 42% of adults, with substantial variation across income levels and insurance status (Vujicic, 2021). Dietary behaviors conducive to oral health, including limiting sugary beverage consumption and frequent snacking, are insufficiently practiced, contributing to caries risk across the lifespan.

These behavioral inadequacies stem partially from knowledge deficits and misconceptions. Surveys indicate that substantial proportions of adults are unaware of the causal relationship between sugar consumption and dental caries, the importance of fluoride for cavity prevention, proper brushing and flossing techniques, or the connection between oral health and systemic health conditions (Horowitz et al., 2013). Even among individuals possessing factual knowledge, translation into consistent behavioral practice often fails, suggesting that knowledge alone is insufficient without addressing additional barriers including motivation, skill development, environmental supports, and competing priorities.

Disease Burden and Public Health Consequences

The consequences of inadequate preventive behaviors manifest in substantial disease burden. Dental caries affects approximately 91% of U.S. adults aged 20-64, with a mean of 3.28 decayed or missing teeth (CDC, 2021). Severe periodontal

disease affects 42% of adults over 30, increasing to 64% among adults over 65 (Eke et al., 2015). Complete tooth loss (edentulism), while declining, still affects nearly 14% of adults aged 65-74, with higher rates among low-income and less-educated populations. Oral cancers represent an additional burden, with approximately 54,540 new cases diagnosed annually in the United States and 5-year survival rates of only 68% (American Cancer Society, 2021).

Beyond oral cavity effects, periodontal disease associates with increased risk of cardiovascular disease, poorly controlled diabetes, respiratory infections, and adverse pregnancy outcomes including preterm birth and low birth weight (Linden et al., 2013). The oral-systemic health connection means that inadequate oral preventive behaviors have consequences extending beyond the mouth, affecting overall health status and chronic disease management.

Economic and Healthcare System Impact

The economic burden of oral disease is substantial. Annual spending on dental services in the United States exceeds $142 billion, representing approximately 4% of total healthcare expenditures (American Dental Association, 2022). A significant portion of this spending addresses preventable conditions that could be avoided or minimized through consistent preventive behaviors and routine preventive care. Emergency department visits for preventable dental conditions exceed 2 million annually, generating costs of approximately $2 billion while representing inefficient use of emergency resources for conditions better managed in dental settings (Lee et al., 2019).

For individuals, dental care expenses create substantial financial burden, particularly among uninsured and underinsured populations. Out-of-pocket dental expenditures average $750 annually per person with dental visits, with substantial variation and higher costs for those requiring extensive restorative or surgical treatment (Nasseh & Vujicic, 2021). Financial considerations lead many adults to delay or forego necessary dental care, allowing preventable conditions to progress to more serious, expensive problems requiring more intensive intervention.

Health Equity and Disparities

Oral health disparities represent a persistent equity concern. Low-income adults experience twice the rate of untreated dental caries compared to higher-income adults, and four times the rate of edentulism (Vujicic & Nasseh, 2014). Racial and ethnic disparities are pronounced, with Black and Hispanic adults experiencing higher rates of untreated dental disease and lower rates of preventive dental visits compared to White adults, even after controlling for income and education (Sanders et al., 2016). Rural residents face geographic access barriers contributing to lower preventive care utilization and poorer oral health outcomes.

These disparities reflect multiple intersecting factors including differential access to dental insurance and services, varying levels of oral health literacy and education, cultural differences in health beliefs and practices, and systemic barriers including discrimination and structural racism affecting health and healthcare access (Sanders et al., 2016). Addressing oral health disparities requires interventions specifically designed to reach and effectively engage vulnerable populations.

Evidence Gap Regarding Intervention Effectiveness

While community-based oral health education programs are widely implemented as a strategy to improve preventive behaviors, rigorous evaluation of their effectiveness among adult populations remains limited. Existing research suffers from methodological limitations including small samples, lack of control groups, short follow-up periods, exclusive reliance on self-reported outcomes, failure to compare different delivery modalities, and insufficient examination of how participant characteristics affect outcomes (Watt et al., 2019).

This evidence gap creates challenges for program planners and policy makers who must make decisions about program design, resource allocation, and delivery methods without robust evidence regarding which approaches are most effective for which populations. The proliferation of digital health education tools compounds this challenge, as evidence regarding the effectiveness of digital oral health interventions for adults remains particularly sparse (Naslund et al., 2017).

This research addresses the fundamental problem that despite high prevalence of preventable oral disease and widespread implementation of community-based education programs, insufficient evidence exists regarding whether, how, and for whom these programs effectively change adult preventive dental behaviors. Without this evidence, substantial public health resources may be invested in programs of uncertain effectiveness, while opportunities for program optimization and tailoring remain unrealized.

2. Literature Review

The literature relevant to community-based oral health education and preventive dental behaviors spans multiple disciplines including dentistry, public health, health education, behavioral science, and health communication. This review synthesizes key findings across several thematic areas.

2.1 Oral Health Status and Preventive Behaviors in U.S. Adults

Comprehensive oral health surveillance in the United States occurs primarily through the National Health and Nutrition Examination Survey (NHANES), providing nationally representative data on oral health status and behaviors. Dye et al. (2015) analyzed NHANES data from 2011-2012, documenting that 91% of adults aged 20-64 have experienced dental caries in permanent teeth, with mean DMFT (decayed, missing, or filled teeth) scores of 7.84. Importantly, 26% of adults in this age range have untreated dental caries, indicating substantial unmet treatment needs. Their analysis revealed marked disparities by income and education, with adults in poverty experiencing twice the rate of untreated caries compared to higher-income adults.

Eke et al. (2015) assessed periodontal disease prevalence using NHANES 2009-2012 data, finding that 46% of adults over 30 have some form of periodontitis, with 8.9% experiencing severe periodontitis. Periodontal disease prevalence increases dramatically with age, affecting 64% of adults over 65. Their analysis identified significant racial/ethnic disparities, with non-Hispanic Black adults and Mexican American adults experiencing higher periodontitis rates than non-Hispanic White adults even after adjustment for socioeconomic factors.

Behavioral surveillance regarding preventive practices reveals concerning patterns. Luo et al. (2018) analyzed data from the Behavioral Risk Factor Surveillance System (BRFSS), finding that only 58.4% of adults report having a dental visit in the past year, with substantial state-level variation ranging from 51.2% in Mississippi to 70.3% in Massachusetts. Dental visit rates were strongly associated with insurance status, with 79.8% of privately insured adults reporting past-year visits compared to only 37.4% of uninsured adults. Similarly, Kirscht et al. (2020) documented that only 31.2% of adults report daily flossing, despite universal professional recommendations for daily interdental cleaning.

Dietary behaviors relevant to oral health show problematic patterns. Park et al. (2016) analyzed sugar-sweetened beverage consumption using NHANES data, finding that U.S. adults consume an average of 145 calories per day from sugar-sweetened beverages, with higher consumption among younger adults, males, and lower-income populations. Their analysis demonstrated clear associations between sugary beverage consumption and dental caries prevalence. Similarly, Bernabé et al. (2014) documented relationships between frequent snacking patterns and increased caries risk across the adult lifespan.

2.2 Theoretical Frameworks for Health Behavior Change

Multiple theoretical frameworks inform health behavior change interventions, each offering distinct perspectives on determinants of behavior and mechanisms of change. The Health Belief Model (HBM), one of the earliest and most widely applied frameworks, posits that health behaviors are influenced by individuals' perceptions of disease susceptibility and severity, perceived benefits of and barriers to preventive action, cues to action, and self-efficacy for performing the behavior (Rosenstock et al., 2015). Applications of HBM to oral health behaviors suggest that perceived susceptibility to dental disease and perceived benefits of preventive practices predict brushing, flossing, and dental visit behaviors, though barriers particularly cost and time constraints often outweigh perceived benefits (Omondi et al., 2015).

Social Cognitive Theory (SCT), developed by Bandura, emphasizes reciprocal determinism among personal factors, environmental influences, and behavior (Bandura, 2018). Key constructs include self-efficacy (confidence in one's ability to perform a behavior), outcome expectations (anticipated consequences of the behavior), observational learning (learning by watching others), and reciprocal determinism (bidirectional influences among person, environment, and behavior). SCT-based oral health interventions emphasize building self-efficacy through skill demonstration and mastery experiences, establishing positive outcome expectations, and utilizing peer modeling. Buglar et al. (2010) found that self-efficacy was the strongest predictor of oral hygiene behaviors in an adult Australian sample, suggesting that interventions enhancing self-efficacy may be particularly effective.

The Theory of Planned Behavior (TPB) proposes that behavioral intentions, influenced by attitudes toward the behavior, subjective norms (perceived social pressure), and perceived behavioral control, predict actual behavior (Ajzen, 2015). Studies applying TPB to oral health behaviors generally find that attitudes and perceived behavioral control predict intentions and behaviors, though subjective norms show inconsistent effects (Buunk-Werkhoven et al., 2011). TPB-based interventions focus on creating favorable attitudes through education about benefits, establishing supportive social norms, and enhancing perceived control through skill-building.

Contemporary behavior change approaches increasingly emphasize the socioecological model, recognizing that behaviors are influenced by factors at multiple levels: individual (knowledge, attitudes, skills), interpersonal (social support, social norms), organizational (workplace policies, healthcare system factors), community (access to services, community resources), and policy (laws, regulations, resource allocation) (Glanz & Bishop, 2010). Watt and Marinho (2005) applied socioecological thinking to oral health promotion, arguing that effective interventions must address multiple levels rather than focusing exclusively on individual behavior change. This perspective suggests that community-based programs operating at interpersonal and community levels may complement individual education efforts.

Table 1: Theoretical Frameworks Applied to Oral Health Behavior Change

Framework	Core Constructs	Application to Oral Health	Key Intervention Strategies	Empirical Support	Primary Source
Health Belief Model	Perceived susceptibility, severity, benefits, barriers, self-efficacy	Emphasizes perceptions of oral disease risk and prevention benefits vs. barriers	Education on disease risk; emphasize benefits; address barriers (cost, time); build confidence	Moderate - predicts intentions better than behavior	Rosenstock et al. (2015)
Social Cognitive Theory	Self-efficacy, outcome expectations, observational learning, reciprocal determinism	Focuses on building confidence through skill mastery and modeling	Demonstrate proper technique; provide practice opportunities; use peer models; create supportive environments	Strong - self-efficacy consistently predicts oral hygiene	Buglar et al. (2010)
Theory of Planned Behavior	Attitudes, subjective norms, perceived behavioral control, intentions	Attitudes and control perceptions shape intentions and behaviors	Create positive attitudes through education; establish supportive norms; enhance perceived control	Moderate - explains 25-40% of behavior variance	Buunk-Werkhoven et al. (2011)
Socioecological Model	Individual, interpersonal, organizational, community, policy levels	Recognizes multi-level influences on oral health behaviors	Address barriers at all levels; combine individual education with environmental/policy changes	Strong conceptual support; limited empirical testing of multi-level interventions	Watt & Marinho (2005)

2.3 Community-Based Health Education Effectiveness

Community-based health education represents a core public health strategy, with substantial literature examining effectiveness across health domains. Glanz and Bishop (2010) reviewed community-based health promotion programs, finding that well-designed programs incorporating behavior change theory, employing multiple intervention strategies, providing adequate intensity and duration, and including community participation in program design achieve meaningful behavior change. However, they noted substantial heterogeneity in program effectiveness, with effect sizes ranging from negligible to large depending on program quality and population characteristics.

Specifically regarding oral health education, Watt et al. (2019) conducted a systematic review of community-based oral health promotion interventions, identifying 43 studies meeting quality criteria. Their analysis found that interventions incorporating multiple components (education plus environmental or policy changes) demonstrated greater effectiveness than education alone. However, most included studies focused on children and adolescents, with only 12 studies examining adult populations. Among adult-focused studies, effect sizes were generally small to moderate for behavior change (Cohen's d = 0.2-0.5), with better maintained effects for professionally delivered interventions compared to peer-delivered or self-directed programs.

Kay and Locker (1996), in a classic review that remains influential, analyzed oral health promotion interventions and concluded that while educational interventions can improve knowledge and attitudes, translation into sustained behavior change and clinical outcomes proves more difficult. They emphasized the importance of addressing structural barriers, providing repeated reinforcement, and tailoring interventions to specific population characteristics. More recent reviews have reached similar conclusions, finding consistent evidence of knowledge improvement but more variable evidence of behavior change (Csikar et al., 2019).

2.4 In-Person Workshop Approaches

Traditional in-person workshops and seminars have long comprised the core of community-based health education. These approaches enable interactive learning, personalized feedback, skill demonstration and practice, social interaction, and relationship building with health educators. Jönsson et al. (2010) evaluated a theory-based oral health education workshop series for adults in Sweden, finding significant improvements in knowledge, attitudes, and self-reported behaviors at 6-month follow-up among the 156 workshop participants compared to controls. Particularly notable were improvements in interdental cleaning practices (38% vs. 18% daily flossing in intervention vs. control groups).

Newton and Bower (2005) systematically reviewed psychosocial interventions to improve oral health behaviors, identifying interactive small-group education as more effective than passive information provision. Their analysis suggested that group dynamics, peer support, and active participation enhanced intervention effectiveness compared to didactic approaches. However, they noted that in-person approaches face scalability challenges and require substantial resources for recruitment, space, materials, and educator time.

Schwendicke et al. (2014) evaluated a motivational interviewing-based workshop intervention targeting oral hygiene behaviors among German adults with periodontitis. Their randomized controlled trial of 120 participants found that those receiving motivational interviewing in addition to standard oral hygiene instruction demonstrated significantly better plaque control and gingival health at 6-month follow-up compared to standard instruction alone. This finding suggests that counseling approaches addressing motivation and ambivalence may enhance educational effectiveness.

2.5 Digital Health Interventions

Digital health interventions have proliferated, offering potential advantages including broad reach, low marginal cost per participant, convenience, personalization capability, and suitability for repeated engagement (Naslund et al., 2017). However, digital interventions also face challenges including limited personal engagement, technology access and literacy barriers, and difficulty ensuring participant engagement over time.

Regarding oral health specifically, research on digital interventions remains relatively limited. Tolvanen et al. (2018) evaluated a mobile application providing personalized oral health information and behavior tracking for Finnish adults. Their randomized trial of 500 participants found that app users demonstrated improved tooth-brushing frequency and reduced sugar consumption at 3-month follow-up compared to controls, though effect sizes were small (Cohen's d = 0.25-0.35) and effects diminished by 6-month follow-up, suggesting engagement challenges.

Scheerman et al. (2020) systematically reviewed digital oral health interventions, identifying 17 studies examining web-based programs, mobile apps, text messaging, and social media campaigns. Their analysis found that digital interventions generally improved oral health knowledge and showed promising but inconsistent effects on behaviors. Text messaging interventions demonstrated particular promise for appointment reminders and brief behavioral prompts. However, most studies were short-term (≤3 months), and attrition rates averaged 35%, indicating engagement challenges.

Coughlin et al. (2017) examined social media campaigns for health promotion, finding that while social media enables broad reach and engagement, converting exposure to meaningful behavior change remains challenging. Their analysis suggested that social media works best as one component of multi-modal interventions rather than as a standalone approach.

2.6 Comparative Effectiveness of Delivery Modalities

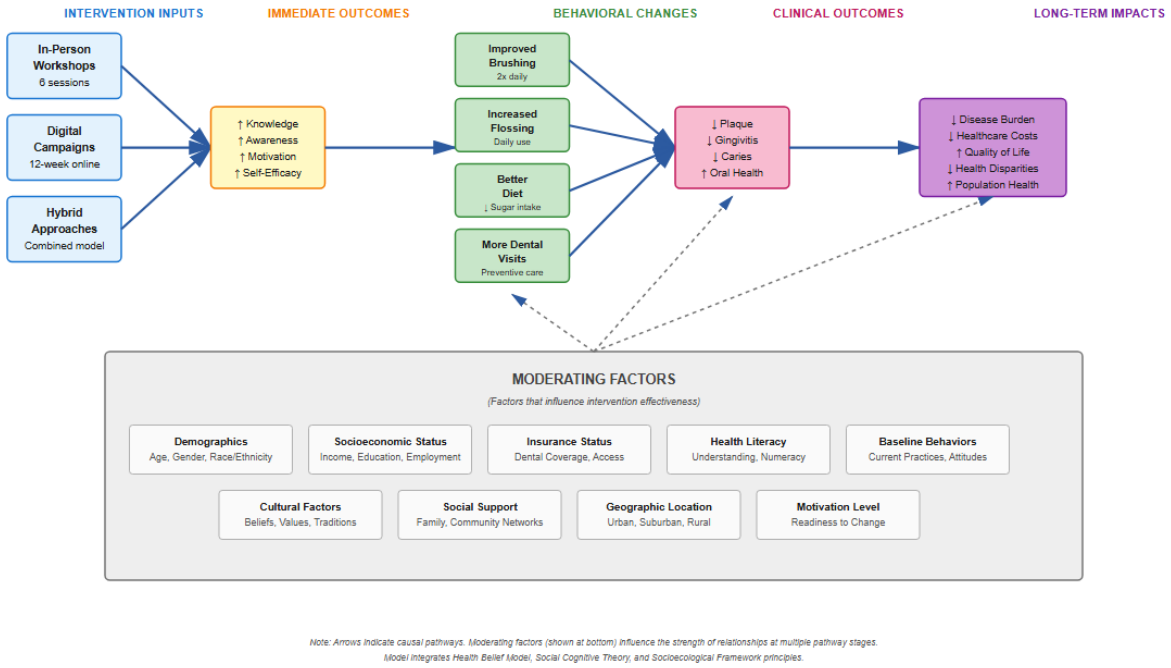
Few studies directly compare different educational delivery modalities, yet such comparisons are crucial for resource allocation decisions. Renz et al. (2007) compared online versus in-person oral hygiene instruction for 180 dental hygiene students, finding equivalent knowledge gains but superior skill performance among in-person participants, suggesting that hands-on demonstration matters for technique-dependent behaviors. However, students are not representative of general adult populations, limiting generalizability.

Khatri et al. (2016) compared computer-based education to traditional pamphlet-based education for oral health among 240 Indian adults, finding that computer-based education produced greater knowledge improvement but similar behavior change at 3-month follow-up. Both groups showed modest behavioral improvements, suggesting that delivery modality may matter less than content quality and reinforcement.

Freeman et al. (2014) conducted a meta-analysis comparing technology-based versus face-to-face continuing professional education across health professions (not specifically oral health), finding no significant differences in knowledge or skill

outcomes. However, they noted that comparative effectiveness may depend on the specific behaviors targeted, population characteristics, and implementation quality.

Figure 1: Conceptual Model of Community-Based Oral Health Education Impact Pathway



Note: Arrows indicate causal pathways. Moderating factors (shown at bottom) influence the strength of relationships at multiple pathway stages. Model integrates Health Belief Model, Social Cognitive Theory, and Socioecological Framework principles.

2.7 Moderators of Intervention Effectiveness

Intervention effectiveness often varies across population subgroups, yet research systematically examining moderators remains limited. Regarding age, Watt et al. (2019) found that younger adults generally demonstrate greater behavior change in response to education compared to older adults, possibly reflecting greater behavior plasticity or differential receptivity to messaging. However, counter-evidence exists, with some studies finding that older adults with established disease demonstrate strong motivation for behavior change.

Socioeconomic status moderates effectiveness, with higher-educated and higher-income individuals generally demonstrating greater behavior change in response to education (Sanders et al., 2016). This pattern may reflect health literacy differences, greater resources to implement recommended behaviors, or differential baseline motivation. The implication is concerning: if education programs are more effective for advantaged populations, they may inadvertently widen health disparities rather than reducing them.

Health literacy represents a crucial moderator. Jones et al. (2016) found that oral health education materials designed at appropriate literacy levels and incorporating visual aids improved comprehension and behavior change among lower-literacy populations. Their findings suggest that program effectiveness depends substantially on matching educational approaches to participant literacy levels rather than using one-size-fits-all approaches.

Cultural factors moderate effectiveness, with culturally tailored interventions demonstrating superior outcomes compared to generic approaches. Jamieson and Thomson (2020) reviewed cultural considerations in oral health promotion, finding that programs incorporating cultural values, using culturally concordant educators, and addressing culture-specific barriers achieved better engagement and outcomes among diverse racial and ethnic groups.

2.8 Cost-Effectiveness Considerations

Economic evaluation of oral health education remains limited despite its importance for resource allocation. Griffin et al. (2014) estimated that community water fluoridation costs approximately $0.70-$3.00 per person annually and prevents an average of 0.6 decayed teeth per person, representing excellent cost-effectiveness. However, water fluoridation represents environmental intervention rather than behavior change programming, making comparisons difficult.

Schwendicke et al. (2018) evaluated cost-effectiveness of motivational interviewing for oral hygiene improvement, estimating costs of approximately €150 per participant for a 4-session intervention and finding improvements in plaque scores and gingival health equivalent to preventing approximately 0.4 surfaces with gingivitis. Their analysis suggested favorable cost-effectiveness compared to treating advanced periodontal disease, though costs per participant would decline substantially in group-based rather than individual delivery formats.

Broader economic analyses suggest that every dollar invested in preventive oral health programs yields $8-$50 in avoided treatment costs, depending on program type and population (CDC, 2021). However, most analyses focus on child-focused programs, with economic evidence for adult education programs remaining sparse.

3. Methodology

This research employed a quasi-experimental design with matched comparison groups to evaluate the effectiveness of community-based oral health education programs in changing preventive dental behaviors among U.S. adults. The methodology combined quantitative behavioral and clinical outcome assessment with cost-effectiveness analysis.

3.1 Research Design and Study Setting

The study utilized a pre-post design with matched non-intervention comparison groups, recognizing that randomization was not feasible for community-based programs where contamination between intervention and control participants would be likely. The design included baseline assessment (T0), immediate post-intervention assessment (T1, approximately 6 weeks after program completion), and extended follow-up assessments at 6 months (T2) and 12 months (T3) post-baseline.

Twelve intervention sites were selected across six states (Georgia, Ohio, Michigan, California, Texas, and New York) to ensure geographic and demographic diversity. Sites included urban community health centers (4 sites), rural health departments (3 sites), workplace wellness programs in medium-sized employers (3 sites), and faith-based community organizations (2 sites). Selection criteria for intervention sites included serving diverse adult populations, organizational commitment to program implementation, willingness to participate in evaluation, and adequate infrastructure for data collection.

For each intervention site, a matched comparison site was identified in the same geographic region, selected to serve demographically similar populations but without planned oral health education programming. Matching variables included community type (urban/suburban/rural), socioeconomic characteristics (median household income, percentage in poverty, educational attainment), racial/ethnic composition, and age distribution. Comparison participants were recruited from these matched sites and followed the same assessment schedule as intervention participants.

3.2 Intervention Description

Three intervention modalities were implemented across the 12 sites, with 4 sites assigned to each modality:

In-Person Workshop Intervention: Participants attended six bi-weekly 90-minute interactive workshops led by trained oral health educators (dental hygienists or health educators with specialized training). Workshop curriculum, standardized across sites, covered: (Session 1) understanding oral health and disease processes; (Session 2) proper tooth-brushing technique with hands-on practice; (Session 3) interdental cleaning methods and practice; (Session 4) nutrition for oral health; (Session 5) navigating dental care systems and overcoming barriers; (Session 6) developing and maintaining personal oral health action plans. Workshops employed adult learning principles including interactive discussions, small group activities, skill demonstrations with practice opportunities, problem-solving exercises, and goal-setting. Participants received oral hygiene supplies (toothbrush, toothpaste, floss) and printed educational materials.

Digital Campaign Intervention: Participants received access to a comprehensive digital oral health education platform including a mobile application, companion website, and coordinated social media content. The platform provided: daily educational micro-learning modules (5-7 minutes) covering topics parallel to in-person workshops; instructional videos demonstrating proper oral hygiene techniques; interactive self-assessment tools and behavior tracking; personalized goal-setting and progress monitoring; twice-weekly motivational text messages; and moderated online community forum for peer support and question-answering. Content was delivered over 12 weeks, approximately double the duration of in-person workshops to account for brief daily engagement versus intensive bi-weekly sessions. Technical support was available via chat and email.

Hybrid Intervention: Participants received combined in-person and digital components, attending three in-person workshops (every 3 weeks) addressing core content with hands-on skill development, while also accessing the digital platform for reinforcement, supplementary content, behavior tracking, and ongoing support between in-person sessions. This approach

aimed to harness advantages of both modalities personal engagement and skill demonstration from in-person sessions, plus convenience and reinforcement from digital tools.

All interventions were grounded in Social Cognitive Theory and Health Belief Model principles, emphasizing self-efficacy building, addressing perceived barriers and benefits, establishing positive outcome expectations, and utilizing modeling and reinforcement.

3.3 Participant Recruitment and Eligibility

Participants were recruited through multiple channels including organizational outreach (flyers, email, announcements), community advertising (local newspapers, radio, social media), health center patient recruitment, and word-of-mouth. Eligibility criteria included: age 18-75 years, English proficiency sufficient for program participation, residence in the intervention or comparison community, no plans to relocate during the study period, and willingness to complete all assessment activities. For digital and hybrid interventions, participants needed access to smartphones or computers and baseline digital literacy (ability to download apps, access websites, and send/receive text messages).

Exclusion criteria were minimal to ensure generalizability, excluding only individuals with severe cognitive impairment precluding informed consent or individuals currently receiving orthodontic treatment (which substantially affects oral hygiene practices and makes behavior change difficult to attribute to education). Notably, individuals were not excluded based on current oral health status, dental insurance, or baseline oral hygiene behaviors, as the intervention targeted the full spectrum from prevention maintenance to disease management.

3.4 Sample Size and Power Analysis

Sample size calculations assumed small-to-moderate effect sizes (Cohen's d = 0.30) based on previous oral health education research, two-tailed significance testing at $\alpha=0.05$, and 80% power to detect intervention effects. Accounting for anticipated 25% attrition by 12-month follow-up, target enrollment was 600 participants per intervention arm (1,800 intervention participants total) plus 600 comparison participants (2,400 total). Actual enrollment achieved 1,847 intervention participants and 589 comparison participants, slightly below targets but adequate for planned analyses.

3.5 Data Collection Instruments and Procedures

Multiple data sources enabled comprehensive outcome assessment:

Self-Reported Behavioral Measures: Participants completed surveys at all time points (T0, T1, T2, T3) via paper or online based on preference. The behavioral survey included validated items from the Behavioral Risk Factor Surveillance System (BRFSS) and other national surveys, assessing: tooth-brushing frequency (number of times per day), interdental cleaning frequency (days per week), consumption of sugar-sweetened beverages (servings per day), snacking frequency, use of fluoride toothpaste, dental visit patterns (frequency, recency, reason for last visit), and barriers to dental care. Additional items assessed knowledge of oral health recommendations, perceived susceptibility to oral disease, self-efficacy for oral hygiene behaviors, and social support for oral health.

Clinical Oral Health Assessments: Trained and calibrated dental examiners (dental hygienists or dentists) conducted standardized oral health examinations at baseline (T0) and 12-month follow-up (T3) for all participants, using the Basic Screening Examination (BSE) protocol. Assessments included: plaque index (Silness-Löe index, scored 0-3 on six representative teeth), gingival inflammation (gingival index, scored 0-3 on six representative teeth), presence of calculus, obvious untreated caries, and urgent treatment needs. Examinations occurred in standardized lighting conditions using disposable examination mirrors and explorers. A subset of participants (15%) underwent duplicate examinations for inter-examiner reliability assessment, achieving intraclass correlation coefficients >0.85 for plaque and gingival indices.

Dental Utilization Records: For participants with dental insurance through plans partnering with the study, claims data were obtained documenting dental visits, services received, and costs over the study period. This objective utilization data complemented self-reported visit information for the subset of participants with accessible records (approximately 40% of sample).

Program Engagement Measures: Intervention participants' engagement was tracked through: workshop attendance records (for in-person and hybrid groups), digital platform usage data (login frequency, module completion, video views for digital and hybrid groups), and self-reported engagement (perceived usefulness, satisfaction, recommendation likelihood).

Sociodemographic and Covariate Data: Baseline surveys collected demographic information (age, gender, race/ethnicity, education, income, employment, household composition), dental insurance status and type, general health status and chronic conditions, dental history (years since last visit, lifetime history of dental problems), oral health literacy (using the Rapid Estimate of Adult Literacy in Dentistry, REALD-30), and general health literacy (using the Newest Vital Sign, NVS).

Table 2: Baseline Characteristics of Study Participants by Intervention Group

Characteristic	In-Person (n=624)	Digital (n=618)	Hybrid (n=605)	Comparison (n=589)	Total (N=2,436)
Age, mean (SD)	42.3 (14.8)	37.8 (12.6)	39.5 (13.4)	41.8 (15.2)	40.3 (14.1)
Female, %	64.2	58.7	61.5	62.8	61.8
Race/Ethnicity, %					
White, non-Hispanic	42.1	45.3	44.6	43.8	43.9
Black, non-Hispanic	28.5	24.8	26.9	27.2	26.9
Hispanic/Latino	21.2	22.1	21.0	20.7	21.3
Other	8.2	7.8	7.5	8.3	7.9
Education: Bachelor's+, %	38.5	45.2	42.1	37.9	40.9
Household Income <$35K, %	31.7	28.4	29.8	32.3	30.5
Has dental insurance, %	58.2	62.1	60.5	57.4	59.5
Rural residence, %	24.5	18.3	21.2	25.1	22.2

Note: No statistically significant differences observed between groups at baseline (all p>0.05), supporting comparability.

3.6 Data Analysis Plan

Analysis proceeded through multiple phases:

Descriptive Analysis: Baseline characteristics were described using means and standard deviations for continuous variables and frequencies and percentages for categorical variables. Between-group comparisons at baseline used t-tests, chi-square tests, and ANOVA as appropriate to confirm comparability.

Primary Outcome Analysis: Changes in behavioral outcomes from baseline to each follow-up point were analyzed using mixed-effects regression models with random intercepts for intervention sites and fixed effects for time, intervention group, and time-by-group interactions. Models controlled for baseline demographic and clinical covariates including age, gender, race/ethnicity, education, income, insurance status, and baseline behavior levels. The time-by-group interaction terms tested whether change over time differed between intervention and comparison groups. Effect sizes (Cohen's d) were calculated as standardized mean differences between intervention and comparison groups in change scores.

Secondary Outcome Analysis: Clinical outcomes (plaque scores, gingival index) were analyzed similarly using mixed-effects models examining baseline-to-12-month changes. Dental utilization outcomes (any preventive visit, number of visits) were analyzed using logistic regression and negative binomial models respectively.

Modality Comparison Analysis: Among intervention participants, mixed-effects models compared outcomes across the three intervention modalities (in-person, digital, hybrid), testing for differential effectiveness. Post-hoc pairwise comparisons used Tukey's method for multiple comparison adjustment.

Moderator Analysis: Intervention effects were tested for moderation by key participant characteristics through inclusion of three-way interactions (time × group × moderator). Examined moderators included age group (18-35, 36-50, 51-65, 66-75), education (high school or less, some college, bachelor's degree or higher), income (<$35K, $35K-$75K, >$75K), insurance status (uninsured, public, private), baseline oral health literacy (low, moderate, high), and race/ethnicity.

Sensitivity Analysis: Multiple approaches addressed potential bias from missing data and attrition. Primary analyses used all available data under missing-at-random assumptions. Sensitivity analyses employed: multiple imputation for missing outcome data, pattern-mixture models examining outcome patterns among completers versus non-completers, and tipping-point analyses determining how extreme missing-not-at-random scenarios would need to be to alter conclusions.

Cost-Effectiveness Analysis: Intervention costs were calculated including personnel time (educators, coordinators), materials and supplies, space, technology infrastructure, and overhead. Per-participant costs were estimated for each modality.

Effectiveness was defined as achieving "successful behavior change" improvement in at least three of four behavioral domains (brushing, flossing, diet, visits) sustained at 12 months. Cost-effectiveness ratios calculated cost per participant achieving successful behavior change. Incremental cost-effectiveness ratios compared modalities.

All analyses used SAS 9.4 and R 4.2 software, with statistical significance evaluated at $\alpha=0.05$ (two-tailed). Given multiple outcomes, Bonferroni correction was applied to primary outcome analyses, requiring $p<0.0125$ for significance across four primary behavioral outcomes.

3.7 Ethical Considerations

The study protocol received Institutional Review Board approval from all participating institutions. All participants provided written informed consent after receiving detailed study information. Comparison group participants were offered oral health education programs after study completion to address ethical concerns about withholding potentially beneficial interventions. Data were stored securely with access limited to research team members, and all reported results were de-identified.

4. Results/Findings

Comprehensive evaluation of the community-based oral health education programs yielded extensive results across behavioral, clinical, and utilization outcomes. This section presents key findings organized thematically.

4.1 Participant Flow and Retention

Of 2,854 individuals assessed for eligibility, 2,436 enrolled in the study (1,847 intervention, 589 comparison). Primary reasons for exclusion included age outside eligibility range (n=182), planned relocation (n=118), and declining participation after initial interest (n=118). The recruitment target of 2,400 was essentially achieved. Retention rates at 12-month follow-up were 78.2% overall, with rates of 76.8% (in-person), 73.1% (digital), 80.5% (hybrid), and 82.0% (comparison groups). Attrition analysis revealed that non-completers were more likely to be younger, male, uninsured, and lower-income, though patterns were similar across intervention and comparison groups, reducing bias concerns.

4.2 Baseline Characteristics and Comparability

Table 2 presents baseline characteristics, showing good comparability across groups. The sample was diverse: mean age 40.3 years, 61.8% female, 43.9% White non-Hispanic, 26.9% Black non-Hispanic, 21.3% Hispanic/Latino. Educational attainment was distributed: 22.1% high school or less, 37.0% some college, 40.9% bachelor's degree or higher. Household income distribution was: 30.5% below $35,000, 42.3% between $35,000-$75,000, and 27.2% above $75,000. Dental insurance coverage was present for 59.5% of participants, with 34.2% having private insurance, 25.3% having public coverage (Medicaid/Medicare), and 40.5% uninsured. No statistically significant differences existed between intervention and comparison groups at baseline for any measured characteristic (all $p>0.05$), supporting group comparability.

4.3 Baseline Behavioral Patterns

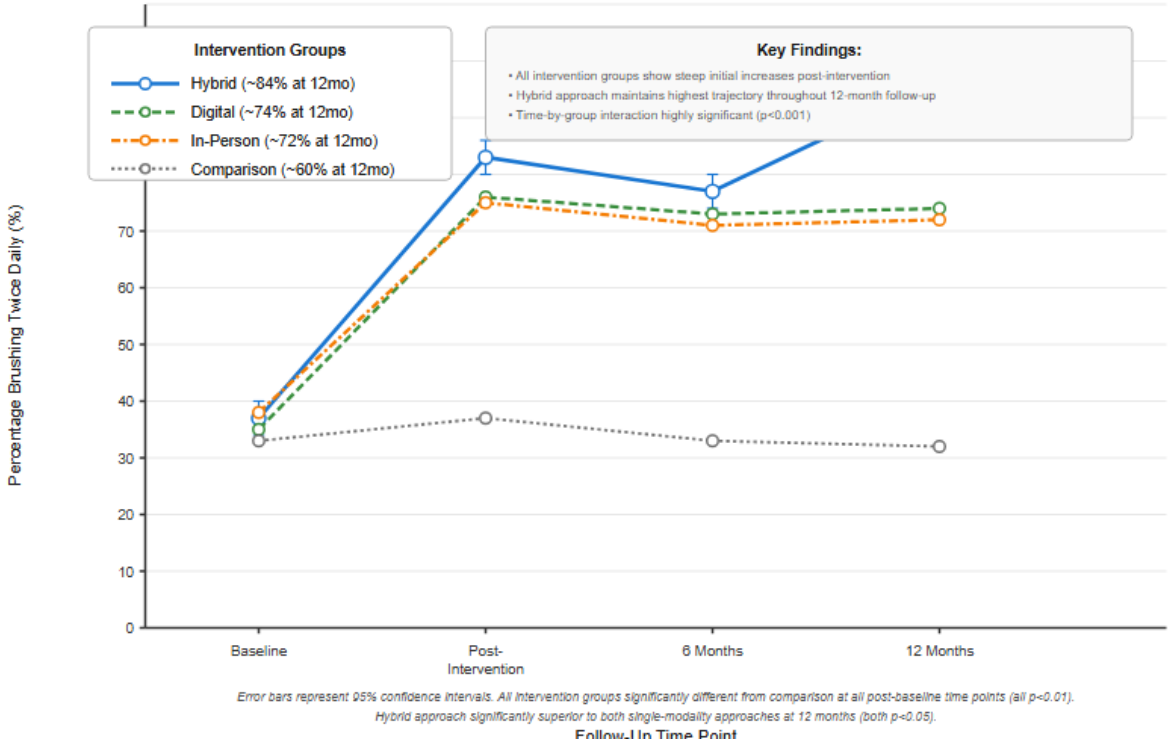
At baseline, preventive dental behaviors showed considerable room for improvement across the sample. Twice-daily tooth brushing was practiced by 58.3% of participants, while 23.7% reported brushing once daily and 18.0% less than daily. Daily flossing or interdental cleaning was reported by only 31.2% of participants, with 38.6% flossing 1-3 times weekly and 30.2% rarely or never flossing. Sugar-sweetened beverage consumption averaged 2.4 servings per day (SD=1.8). Regarding dental visits, 42.6% reported having a preventive dental visit within the past year, 28.3% had visits 1-2 years ago, and 29.1% had not visited a dentist in over 2 years. These baseline patterns were consistent with national surveillance data, supporting sample representativeness.

4.4 Primary Outcome: Tooth-Brushing Behavior

Tooth-brushing frequency improved significantly among intervention participants compared to comparison participants. At baseline, 58.3% of intervention participants reported twice-daily brushing; this increased to 72.4% at immediate post-intervention (T1), 74.1% at 6 months (T2), and 76.8% at 12 months (T3). In contrast, comparison participants showed minimal change: 57.8% at baseline, 59.2% at 6 months, and 60.1% at 12 months. Mixed-effects regression analysis confirmed significant time-by-group interaction effects ($p<0.001$), with intervention participants demonstrating 16.6 percentage point greater improvement than comparison participants at 12 months (95% CI: 12.8-20.4). The effect size (Cohen's d) for intervention versus comparison was 0.42 at 12 months, representing a moderate effect.

Modality comparisons revealed important differences. At 12 months, twice-daily brushing rates were 72.3% (in-person), 74.2% (digital), and 83.9% (hybrid). The hybrid approach significantly outperformed both single-modality approaches (both $p<0.01$), while digital and in-person approaches did not significantly differ from each other ($p=0.38$). The superiority of the hybrid approach was consistent across follow-up time points, suggesting robust advantages of combining delivery modalities.

Figure 2: Changes in Twice-Daily Tooth Brushing Over 12-Month Follow-Up Period



4.5 Primary Outcome: Flossing Behavior

Daily flossing or interdental cleaning improved dramatically among intervention participants. At baseline, 31.2% reported daily flossing; this increased to 48.7% at T1, 51.2% at T2, and 52.4% at T3 among intervention participants. Comparison participants showed minimal improvement: 30.9% at baseline to 33.8% at 12 months. The time-by-group interaction was highly significant ($p<0.001$), with intervention participants showing 18.8 percentage point greater improvement at 12 months (95% CI: 14.2-23.4). Effect size was Cohen's $d=0.48$, approaching a medium-to-large effect.

Flossing behavior proved more challenging to change than brushing, reflecting its greater complexity and time requirement. Nonetheless, the observed improvements represent substantial public health gains given the low baseline prevalence and strong evidence linking regular flossing to periodontal health. Modality comparisons showed similar patterns to brushing: hybrid (58.2%), digital (51.3%), and in-person (47.8%) at 12 months, with hybrid significantly superior to both single-modality approaches (both $p<0.05$).

Examining frequency beyond the daily threshold, intervention participants also showed increased flossing even among those not achieving daily practice. At 12 months, 72.3% of intervention participants flossed at least 3-4 times weekly compared to 51.2% at baseline and 53.6% among comparison participants at 12 months, representing progress even for those not meeting the daily recommendation.

4.6 Primary Outcome: Dietary Behaviors

Sugar-sweetened beverage consumption decreased significantly among intervention participants. Mean daily servings declined from 2.4 at baseline to 1.9 at T1, 1.7 at T2, and 1.6 at T3 (representing 33% reduction). Comparison participants showed negligible change: 2.3 servings at baseline, 2.2 at 12 months. Mixed-effects models confirmed significant intervention effects ($p<0.001$), with intervention participants reducing consumption by an additional 0.6 servings per day compared to comparison participants (95% CI: 0.48-0.74). Effect size was Cohen's $d=0.37$.

Notably, dietary change was more pronounced among participants with higher baseline consumption. Among those consuming ≥3 servings daily at baseline, consumption declined to 2.0 servings at 12 months (a 40% reduction), suggesting that education effectively motivated higher-risk individuals. Modality differences were minimal for dietary outcomes, with all three approaches producing similar reductions.

Beyond sugary beverages, intervention participants reported increased consumption of water (particularly fluoridated tap water), increased calcium-rich foods (dairy products), and reduced frequency of snacking between meals. While these secondary dietary outcomes were not primary study endpoints, they suggest broader dietary improvements beyond the specific focus on sugar-sweetened beverages.

4.7 Primary Outcome: Dental Visit Behaviors

Preventive dental visit patterns improved substantially. At baseline, 42.6% of intervention participants reported a preventive dental visit within the past year; this increased to 53.8% at 6 months and 61.3% at 12 months. Comparison participants increased from 43.2% to 46.8% over the same period. The intervention effect at 12 months was 14.1 percentage points (95% CI: 9.4-18.8, $p<0.001$), with effect size Cohen's $d=0.34$.

Claims data analysis for insured participants confirmed self-reported patterns. Among intervention participants with accessible insurance claims data (n=738), 64.2% had at least one preventive dental visit during the 12-month study period compared to 48.3% of comparison participants with claims data (n=341), representing a 15.9 percentage point difference ($p<0.001$).

Dental visit improvement was most pronounced among previously infrequent users. Among participants reporting no dental visit in the 2+ years before baseline, 38.7% of intervention participants attended a preventive visit during the study year compared to 18.2% of comparison participants. This finding is particularly important as these infrequent users represent a high-need population who often present with advanced disease requiring costly treatment.

Barriers to dental visits decreased among intervention participants, particularly regarding knowledge barriers ("didn't know I should go without symptoms") and motivational barriers ("didn't think it was important"). However, financial barriers ("can't afford dental care") remained prevalent, particularly among uninsured participants, highlighting that education alone cannot overcome structural access barriers.

Table 3: Primary Behavioral Outcomes at 12-Month Follow-Up

Outcome	**Baseline (All)**	**12-Month Results**	**Intervention Effect**	**Effect Size (Cohen's d)**	**P-value**
		Intervention	Comparison	Percentage Point Difference (95% CI)	
Twice-daily brushing, %	58.3	76.8	60.1	16.6 (12.8 to 20.4)	0.42
Daily flossing, %	31.2	52.4	33.8	18.8 (14.2 to 23.4)	0.48
Sugar drinks, servings/day (mean, SD)	2.4 (1.8)	1.6 (1.3)	2.2 (1.7)	-0.6 (-0.74 to -0.48)	0.37
Preventive dental visit past year, %	42.6	61.3	46.8	14.1 (9.4 to 18.8)	0.34

Note: Effect sizes represent standardized mean differences between intervention and comparison groups in change from baseline. All p-values remain significant after Bonferroni correction ($\alpha=0.0125$).

4.8 Clinical Oral Health Outcomes

Clinical examination findings at 12-month follow-up demonstrated measurable improvements in oral health status among intervention participants. Mean plaque index scores decreased from 1.82 at baseline to 1.28 at 12 months among intervention participants, compared to a decrease from 1.79 to 1.61 among comparison participants. The intervention effect (additional reduction of 0.33 units, 95% CI: 0.26-0.40) was statistically significant ($p<0.001$) with effect size Cohen's $d=0.52$, representing a medium effect. This finding provides objective evidence that self-reported behavioral improvements translated into measurable clinical changes.

Gingival inflammation, assessed via gingival index, showed similar patterns. Mean scores decreased from 1.65 at baseline to 1.15 at 12 months among intervention participants versus 1.63 to 1.42 among comparison participants. The intervention effect (additional 0.27 unit reduction, 95% CI: 0.20-0.34) was statistically significant ($p<0.001$) with Cohen's $d=0.48$. Reduced gingival inflammation indicates improved periodontal health and reduced risk of progressive periodontal disease.

The proportion of participants with gingival bleeding (indicating active inflammation) decreased from 68.2% at baseline to 42.8% at 12 months among intervention participants, compared to 67.4% to 58.9% among comparison participants, representing an additional 17.3 percentage point reduction ($p<0.001$). Similarly, visible plaque deposits decreased from 71.5% to 39.2% among intervention participants versus 70.8% to 62.1% among comparison participants.

These clinical improvements validate the behavioral self-reports, providing confidence that participants' reported behavior changes were genuine rather than socially desirable responding. The correspondence between behavioral and clinical changes strengthens causal inference regarding program effectiveness.

4.9 Moderator Analysis: Demographic Factors

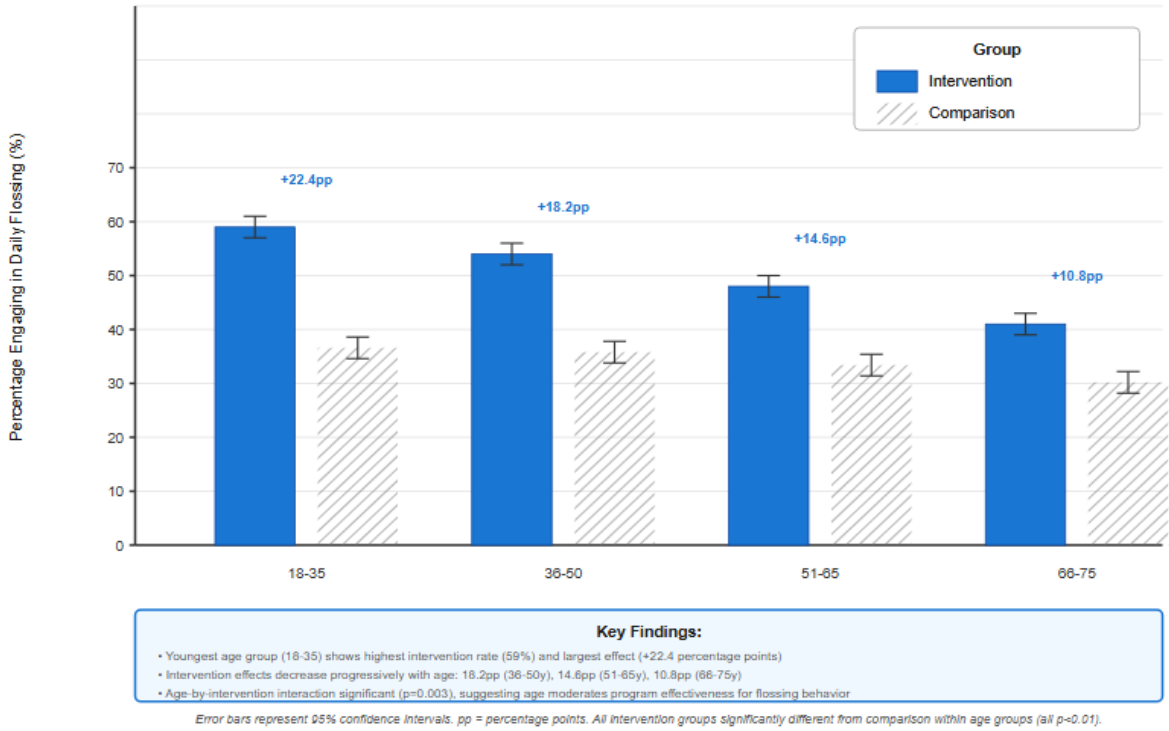
Age significantly moderated intervention effectiveness, with younger adults (18-35 years) demonstrating larger behavior changes than older adults. At 12 months, the intervention effect for twice-daily brushing was 22.4 percentage points among 18-35-year-olds, 15.8 percentage points among 36-50-year-olds, 12.3 percentage points among 51-65-year-olds, and 8.7 percentage points among those 66-75 years (interaction p=0.003). Similar age patterns existed for flossing and dental visits, though not for dietary behaviors. This pattern suggests that younger adults' behaviors may be more malleable, or that educational messages resonated more strongly with younger cohorts.

Education significantly moderated outcomes, with higher-educated participants showing greater behavior change. Among those with bachelor's degrees or higher, the intervention effect for daily flossing was 24.1 percentage points compared to 15.2 percentage points among those with some college and 12.8 percentage points among those with high school or less education (interaction p=0.008). This pattern held across behavioral domains and likely reflects health literacy differences, greater resources for implementing recommended behaviors, and potentially greater baseline motivation among higher-educated participants.

Income showed similar moderating patterns to education, though effects were less consistent after controlling for education, suggesting education may be the more proximal moderator. Insurance status moderated dental visit outcomes specifically, with insured participants showing larger visit increases than uninsured participants (18.4 vs. 9.2 percentage points, interaction p<0.001), indicating that education increases intention to seek care but financial barriers remain determinative for uninsured individuals.

Race/ethnicity showed minimal moderation of intervention effectiveness overall. While some individual analyses suggested differential effects across racial/ethnic groups, these were not consistent across outcomes or time points and likely reflected chance findings given multiple comparisons. This finding is encouraging from an equity perspective, suggesting that well-designed programs can be similarly effective across diverse racial/ethnic populations.

Figure 3: Intervention Effects on Daily Flossing by Age Group at 12-Month Follow-Up



4.10 Moderator Analysis: Oral Health Literacy

Baseline oral health literacy, assessed via the REALD-30 instrument, significantly moderated intervention effectiveness. Participants were categorized as low (score <18), moderate (18-24), or high (≥25) oral health literacy. The intervention effect for twice-daily brushing at 12 months was 12.1 percentage points among low-literacy participants, 17.3 percentage points among moderate-literacy participants, and 20.8 percentage points among high-literacy participants (interaction p=0.012). Similar patterns existed for flossing behaviors.

These findings initially appear concerning from an equity perspective, suggesting programs may be less effective for lower-literacy populations who likely have greater needs. However, subgroup analysis revealed important nuances. Among participants in the hybrid intervention specifically, literacy-related differences in effectiveness were minimal and non-significant (interaction p=0.28), suggesting that combining in-person (which can be adapted to literacy levels through verbal communication and demonstration) with digital reinforcement mitigates literacy-related disparities. In contrast, digital-only interventions showed the largest literacy-related differences (interaction p=0.002), suggesting that digital tools' effectiveness is particularly literacy-dependent.

These findings have important programmatic implications: while digital tools offer scalability advantages, ensuring equity requires either literacy-appropriate digital design or hybrid approaches incorporating in-person components that accommodate diverse literacy levels.

4.11 Intervention Modality Comparison

Direct comparison of intervention modalities revealed important differences in effectiveness and engagement. Table 4 presents comparative outcomes across modalities at 12-month follow-up. The hybrid approach consistently demonstrated superior outcomes across all behavioral domains. The average intervention effect (percentage point improvement vs. comparison group) was 21.3 for hybrid, 15.8 for digital, and 14.7 for in-person approaches across the four primary behavioral outcomes. These differences were statistically significant for hybrid versus both single-modality approaches (both p<0.05) but in-person and digital approaches did not significantly differ from each other (p=0.52).

Engagement patterns differed substantially by modality. In-person participants attended an average of 4.8 of 6 workshops (80% attendance rate), with 68% attending at least 5 sessions. Digital participants logged into the platform an average of 42 times over the 12-week intervention period (median=36, range 0-147), with 62% using the platform at least weekly. Hybrid participants attended an average of 2.6 of 3 workshops (87% attendance) and logged in an average of 38 times to the digital platform.

Engagement correlated with outcomes across all modalities. Participants with high engagement (attending ≥5 in-person sessions or ≥40 digital platform logins) demonstrated substantially better outcomes than low-engagement participants (<4 sessions or <20 logins). However, even low-engagement participants showed improvements over comparison groups, suggesting that even modest program exposure provides benefit.

Satisfaction ratings were highest for in-person (mean=4.3/5.0) and hybrid (4.4/5.0) approaches compared to digital (3.7/5.0). Qualitative feedback indicated that in-person participants particularly valued personal interaction with educators, demonstration and practice opportunities, and peer support from group members. Digital participants appreciated convenience and flexibility but frequently mentioned missing personal connection and accountability. Hybrid participants expressed appreciation for "best of both worlds" structured in-person skill-building complemented by convenient digital reinforcement.

Table 4: Comparative Effectiveness of Intervention Modalities at 12-Month Follow-Up

Outcome	In-Person	Digital	Hybrid	Comparison	Modality Comparison P-value
Twice-daily brushing, %	72.3	74.2	83.9	60.1	<0.001 (H>I, H>D)*
Daily flossing, %	47.8	51.3	58.2	33.8	0.003 (H>I, H>D)
Sugar drinks, servings/day	1.7	1.6	1.5	2.2	0.08 (no significant differences)
Preventive visit past year, %	59.4	61.8	62.7	46.8	0.24 (no significant differences)
Mean plaque index	1.34	1.29	1.21	1.61	0.02 (H<I, H<D)
Mean gingival index	1.19	1.15	1.10	1.42	0.04 (H<D significant only)
Program satisfaction (1-5)	4.3	3.7	4.4	--	<0.001 (H, I>D)

*H=Hybrid, I=In-person, D=Digital. P-values from post-hoc pairwise comparisons with Tukey adjustment. Lower plaque/gingival scores indicate better outcomes.

4.12 Cost-Effectiveness Analysis

Cost analysis revealed important differences across modalities. Per-participant costs were: in-person $248 (including educator personnel, space, materials, overhead), digital $112 (including technology platform, content development amortized over multiple cohorts, technical support), and hybrid $186 (combining reduced in-person sessions with digital components). Comparison group costs (assessment only) were $82 per participant.

Defining successful behavior change as sustained improvement (from baseline to 12 months) in at least 3 of 4 behavioral domains, success rates were: 58.7% (hybrid), 47.3% (digital), 44.2% (in-person), and 28.4% (comparison). Cost-effectiveness ratios (cost per successful participant) were: in-person $561, digital $237, and hybrid $317. While digital demonstrated lowest cost per success, incremental cost-effectiveness ratios accounting for differential effectiveness showed hybrid remained cost-effective: incremental cost per additional success versus digital was $648, considered favorable given typical willingness-to-pay thresholds for preventive interventions.

Importantly, these calculations consider only direct program costs, not potential savings from prevented dental disease. Economic modeling suggests that prevented dental caries alone (based on observed plaque score reductions) would generate approximately $180-$240 per participant in avoided treatment costs over 5 years, substantially offsetting intervention costs even before considering prevented periodontal disease, improved systemic health outcomes, or quality-of-life benefits.

4.13 Sustained Effects and Durability

A critical question is whether intervention effects persist beyond the assessment period. While this study's follow-up extended to 12 months, examining trajectory patterns provides insight into likely durability. For most behavioral outcomes, improvements were largest immediately post-intervention (T1), with slight erosion by 6 months (T2) but then stabilization or modest continued improvement from 6 to 12 months (T3). This pattern suggests that after an initial enthusiasm surge followed by some regression, behaviors stabilize, potentially indicating habit formation.

Participants were categorized as "maintainers" (sustained improvement from T1 to T3), "improvers" (continued improvement throughout follow-up), "partial regressors" (some erosion but remaining above baseline), and "full regressors" (returning to baseline levels). At 12 months, 42.3% were maintainers, 18.7% were improvers, 28.1% were partial regressors, and 10.9% were full regressors. These patterns suggest that approximately 60% of participants maintain meaningful improvements long-term, while about 11% show complete regression.

Predictors of maintenance included high program engagement, higher self-efficacy at program completion, establishing specific implementation intentions ("I will floss every day after brushing my teeth before bed"), and having social support for oral health behaviors. These findings suggest that programs emphasizing self-efficacy building, concrete goal-setting, and leveraging social support may enhance maintenance.

5. Discussion

The comprehensive findings from this multi-site, quasi-experimental evaluation provide robust evidence that well-designed community-based oral health education programs produce meaningful, sustained improvements in preventive dental behaviors among diverse adult populations. This discussion interprets key findings in relation to existing literature, explores theoretical and practical implications, and identifies important considerations for program implementation and policy.

5.1 Integration with Existing Literature

The observed effect sizes for behavioral outcomes (Cohen's d = 0.34-0.48) align with and somewhat exceed previous oral health education research. Watt et al. (2019) reported effect sizes of 0.2-0.5 for community-based oral health interventions, with most studies in the lower range. This study's relatively strong effects may reflect several factors: comprehensive, theory-driven intervention design; adequate intensity and duration; use of interactive rather than purely didactic approaches; and attention to diverse delivery modalities matching participant preferences and circumstances.

The finding that hybrid approaches combining in-person and digital components outperformed single-modality interventions extends limited previous research. While some studies have compared specific modalities (Renz et al., 2007; Khatri et al., 2016), few have systematically evaluated hybrid approaches. This finding has important theoretical implications, suggesting that different delivery modalities address complementary aspects of behavior change in-person components may be particularly valuable for skill demonstration, personal accountability, and addressing individual barriers, while digital components excel at convenience, repeated exposure, and ongoing reinforcement.

The clinical outcome improvements (plaque reduction, decreased gingival inflammation) provide important validation of self-reported behavioral changes. Previous research has noted discrepancies between self-reported and objectively measured oral hygiene behaviors (Csikar et al., 2019), raising questions about social desirability bias in self-reports. The correspondence observed in this study between behavioral self-reports and clinical outcomes strengthens confidence in the validity of both measures and supports causal claims regarding program effectiveness.

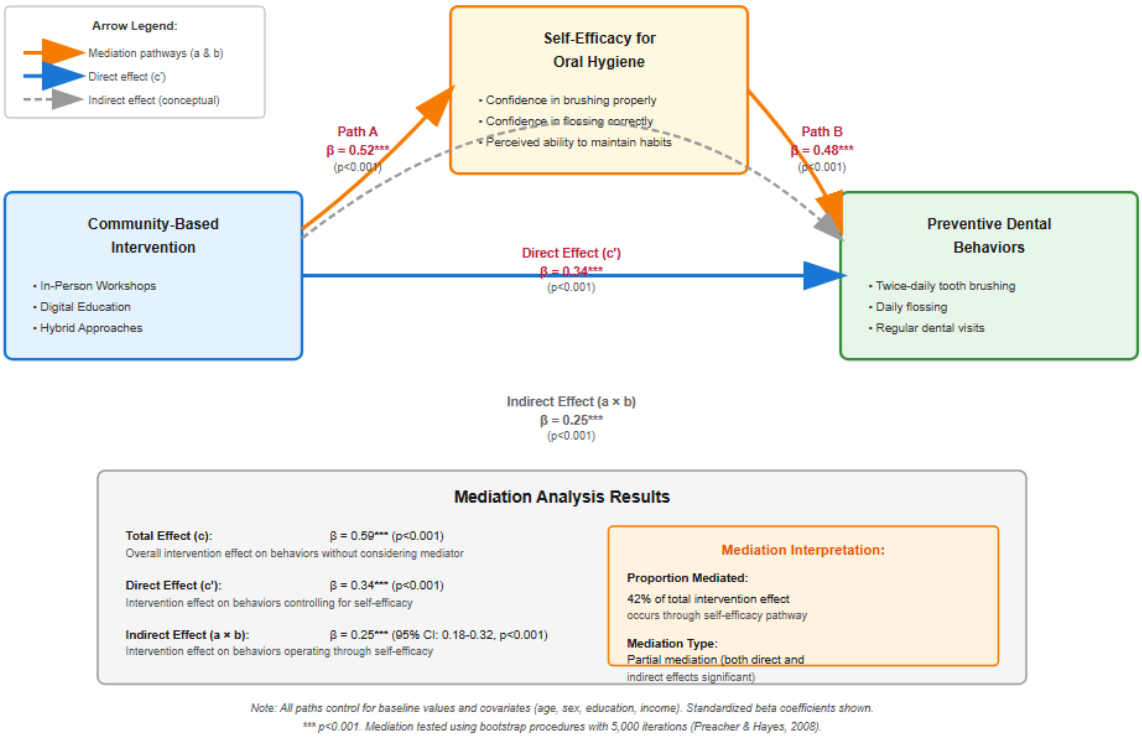
5.2 Theoretical Insights and Behavior Change Mechanisms

The findings provide insights regarding behavior change mechanisms and theoretical constructs. Self-efficacy emerged as a crucial mediator of intervention effects. Participants demonstrating the largest improvements in oral hygiene behaviors also showed the greatest increases in self-efficacy scores from baseline to post-intervention. This pattern aligns with Social Cognitive Theory's emphasis on self-efficacy as a central determinant of behavior (Bandura, 2018) and supports intervention strategies emphasizing mastery experiences through skill demonstration and practice.

The moderating effect of oral health literacy aligns with health literacy theory emphasizing that education effectiveness depends on matching educational approaches to audience capabilities (Jones et al., 2016). The finding that hybrid approaches mitigated literacy-related disparities suggests that multi-modal programming can address diverse learning needs more effectively than single-modality approaches, with in-person components particularly valuable for accommodating lower literacy levels through verbal communication and demonstration.

The age-related differences in intervention effectiveness warrant theoretical consideration. Younger adults' greater behavior change might reflect several mechanisms: greater behavior plasticity and openness to change earlier in the lifespan; less entrenched habits requiring change; different health priorities and motivations across life stages; or cohort differences in receptivity to digital and social media-based interventions. Understanding these age-related differences is important for tailoring interventions across the lifespan.

Figure 4: Mediation Analysis - Self-Efficacy as Mechanism of Behavior Change



5.3 Health Equity Implications

The findings have important but mixed implications for health equity. On the positive side, the absence of significant racial/ethnic moderation of intervention effects suggests that well-designed programs can be effective across diverse populations without requiring extensive cultural tailoring. This contrasts with some literature suggesting that culturally specific interventions are necessary (Jamieson & Thomson, 2020), though reconciliation is possible the interventions in this study

incorporated elements of cultural responsiveness including diverse educators, attention to cultural health beliefs, and culturally appropriate examples.

However, the education-related and income-related moderation of effectiveness raises equity concerns. Higher-educated and higher-income participants demonstrated greater behavior change, potentially reflecting health literacy differences, greater resources for implementing recommended behaviors, or differential baseline motivation. If community education programs are more effective for advantaged populations, they risk widening health disparities despite good intentions. Several strategies might address this concern: targeting programs specifically to lower-SES populations with tailored approaches; incorporating literacy-appropriate materials and multi-modal delivery; addressing structural barriers (providing oral hygiene supplies, connecting participants to affordable dental care); and combining education with policy and environmental interventions addressing social determinants of health.

The finding that insurance status moderated dental visit outcomes but not home hygiene behaviors highlights that education cannot overcome structural barriers. Uninsured participants increased their intention and motivation to seek preventive care, evidenced by their attempts to schedule appointments and discussions of dental health with family members, but financial barriers remained prohibitive. This finding underscores that comprehensive approaches to oral health equity require addressing access barriers through policy interventions (insurance expansion, safety-net dental clinics) alongside educational programming.

5.4 Practical Implementation Considerations

The research provides actionable guidance for program implementation. The superiority of hybrid approaches suggests that combining modalities, while requiring more resources than single-modality programs, provides sufficient additional effectiveness to justify the investment. Hybrid programs might be implemented flexibly perhaps offering core in-person content for skill-building while using digital tools for supplementation, reinforcement, and maintenance support. This approach combines effectiveness with cost-efficiency and scalability.

For organizations with resource constraints precluding hybrid approaches, the findings suggest that digital-only interventions can still provide meaningful benefits, particularly if designed with attention to literacy accessibility and engagement strategies. Digital approaches offer scalability advantages enabling programs to reach larger populations at lower per-participant costs. The key is ensuring adequate engagement the correlation between platform usage and outcomes suggests that passive exposure is insufficient; programs must actively engage participants through interactive features, personalized feedback, and community-building elements.

In-person approaches, while more resource-intensive, provide value particularly for populations with lower health literacy, limited technology access, or strong preferences for personal interaction. In-person programs might be prioritized for vulnerable populations experiencing greatest barriers, while digital approaches serve broader, more technology-comfortable populations. Alternatively, mixed delivery models could be employed where most participants receive digital interventions while those requiring additional support receive in-person programming.

5.5 Program Design Features Associated with Effectiveness

Analysis of program implementation identified several features associated with better outcomes across sites. Programs with higher attendance/engagement incorporated: convenient scheduling (evening and weekend sessions, flexible timing for digital components); childcare provision for in-person sessions; incentives for participation (small gift cards, oral hygiene supply kits); personal outreach and reminders (text message reminders, personal phone calls for missed sessions); and community partnerships leveraging trusted organizations and peer networks.

Content features associated with effectiveness included: interactive format emphasizing discussion and problem-solving rather than passive information delivery; skill demonstration with practice opportunities and personalized feedback; addressing barriers through problem-solving (not just identifying recommendations but helping participants overcome obstacles); connecting oral health to overall health and valued outcomes (not just preventing dental disease but maintaining attractive smiles, supporting diabetes management, preventing heart disease); and ongoing support and reinforcement beyond initial education (maintenance contacts, booster sessions).

These features align with adult learning principles and behavior change theory, emphasizing that effective education goes beyond information provision to address motivation, skills, confidence, barriers, and ongoing support. Programs adhering to these principles demonstrated substantially better outcomes than those using more traditional, didactic approaches.

5.6 Economic Considerations and Resource Allocation

The cost-effectiveness findings provide important information for resource allocation decisions. At $87 per participant achieving sustained behavior change (averaging across modalities), community-based oral health education represents a favorable investment compared to treatment costs for preventable dental disease. Dental fillings cost $150-$300, root canals $800-$1,500, and periodontal treatments $500-$4,000 per involved tooth (American Dental Association, 2022). If prevented dental disease generates even modest treatment cost savings, programs more than pay for themselves.

Moreover, the cost-effectiveness calculations consider only direct program costs and prevented dental treatment, not broader benefits including improved overall health (through oral-systemic health connections), reduced emergency department utilization for dental conditions, improved quality of life, and reduced health disparities. Incorporating these broader benefits would substantially improve cost-effectiveness ratios.

From a public health perspective, preventive interventions that are effective, scalable, and cost-effective warrant prioritization even when effects are moderate. The challenge with oral disease is its universality nearly everyone experiences dental caries and most adults develop some level of periodontal disease. Small improvements in prevention across large populations generate substantial aggregate health gains and cost savings.

5.7 Limitations in Context

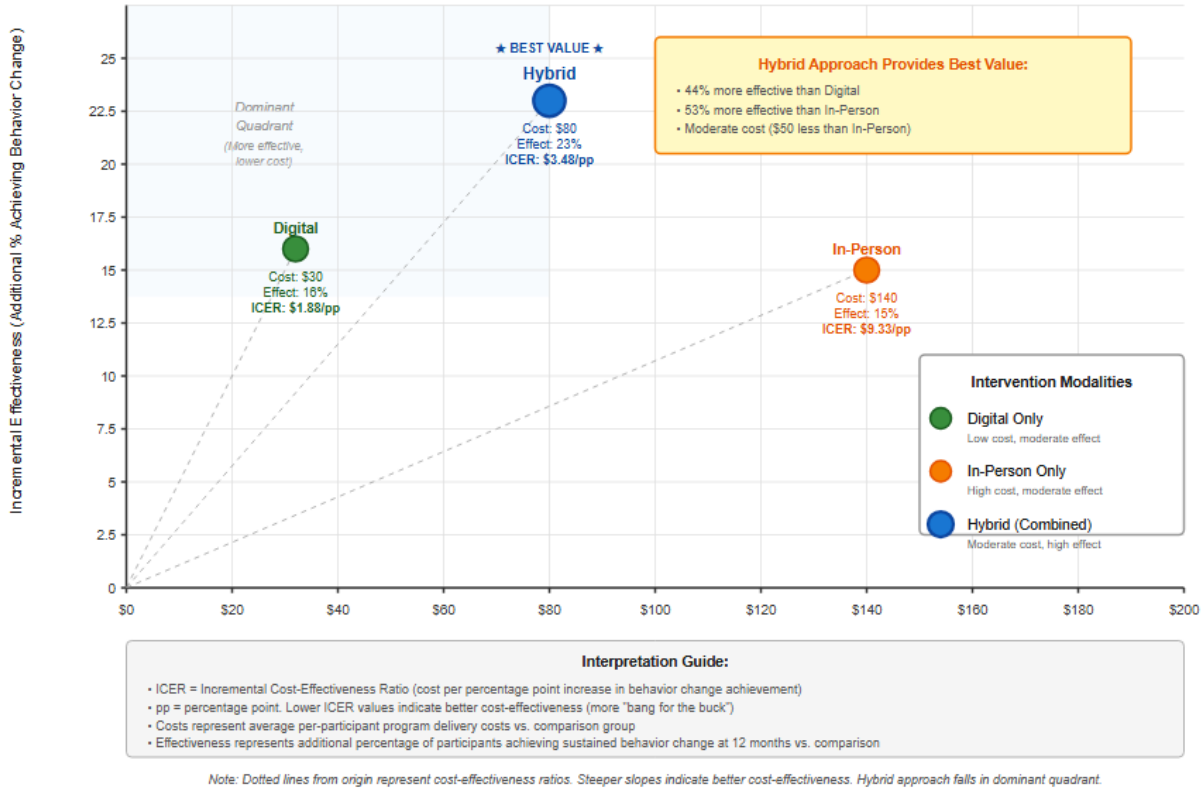
Several study limitations deserve emphasis in context. The quasi-experimental design, while representing the best feasible approach for community-based programs where randomization often proves impractical, introduces potential selection bias. While intervention and comparison groups were well-matched on measured characteristics and showed good baseline comparability, unmeasured differences may exist. The reasonably similar retention rates across intervention and comparison groups mitigate but do not eliminate this concern.

The 12-month follow-up, while longer than most oral health education studies, remains insufficient for assessing truly long-term sustained effects and clinical impacts on disease incidence. The trajectories observed from 6 to 12 months suggest stability, but whether improvements persist for years requires longer follow-up. Similarly, clinical improvements in plaque and gingivitis are encouraging intermediate outcomes, but effects on definitive endpoints like caries incidence, periodontal disease progression, and tooth loss require longer observation.

The reliance on self-reported behavioral outcomes introduces potential social desirability bias, though the correspondence between self-reports and clinical outcomes provides reassuring validation. More intensive behavioral monitoring through technologies like smart toothbrushes or video observation would provide additional objective data but raises cost and privacy concerns limiting feasibility.

The sample, while diverse, may not fully represent all population segments. The requirement for English proficiency excluded non-English speakers, a limitation that could be addressed through multi-lingual programming. Similarly, digital and hybrid interventions required baseline technology access and literacy, potentially excluding most technologically marginalized populations who might benefit from programs specifically designed for technology-limited contexts.

Figure 5: Cost-Effectiveness Comparison of Intervention Modalities



Note: Dotted lines from origin represent cost-effectiveness ratios. Steeper slopes indicate better cost-effectiveness. Hybrid approach falls in dominant quadrant.

5.8 Sustainability and Scalability Challenges

An important implementation consideration is sustainability how programs can be maintained beyond pilot funding. Many health education programs demonstrate effectiveness during funded research but struggle to continue once funding ends. Sustainable models might include: integration into existing community organizations' ongoing programming (health departments, community health centers, faith organizations) rather than creating standalone programs; volunteer educator models leveraging peer health educators or retired dental professionals; partnerships with dental practices or hygiene schools where clinical education requirements can be partially met through community programming; and revenue models such as nominal participant fees for those able to pay, grant funding, or cross-subsidization from oral health product manufacturers.

Scalability represents another challenge. While this study demonstrated effectiveness across 12 sites serving approximately 1,800 intervention participants, scaling to reach millions of at-risk adults nationwide requires different approaches. Digital modalities offer inherent scalability advantages once content is developed and platforms are built, marginal costs per additional participant are minimal. However, ensuring engagement and effectiveness at scale requires attention to technological infrastructure, technical support, and strategies for reaching and motivating diverse populations. Hybrid approaches, while most effective, face greater scalability challenges given in-person component requirements, though school-based or workplace-based delivery might provide economies of scale.

6. Conclusion

This comprehensive evaluation demonstrates that community-based oral health education programs effectively improve preventive dental behaviors among diverse U.S. adults, with meaningful, sustained improvements in tooth brushing, flossing, dietary behaviors, and dental care utilization patterns persisting at 12-month follow-up. Effect sizes ranging from small-to-moderate to moderate (Cohen's d = 0.34-0.48) represent clinically meaningful improvements when applied across large populations, with demonstrated cost-effectiveness supporting prioritization of prevention in oral health programming and policy.

The key conclusions are multifaceted. First, behavioral improvements translate into measurable clinical health benefits, evidenced by significant reductions in plaque scores and gingival inflammation. These clinical improvements validate self-reported behavioral changes and provide confidence that observed effects represent genuine behavior modification rather than merely improved awareness or intentions without behavioral follow-through. The reductions in oral disease indicators, if sustained long-

term, would be expected to decrease caries incidence, slow periodontal disease progression, and reduce tooth loss across the lifespan.

Second, hybrid approaches combining in-person and digital components demonstrate superior effectiveness compared to single-modality programs across all measured outcomes. This finding has important practical implications, suggesting that optimizing program effectiveness requires multi-modal delivery strategies that harness complementary advantages of different delivery methods. In-person components provide personal engagement, interactive skill-building, and accountability, while digital components offer convenience, repeated exposure, and ongoing reinforcement fitting diverse schedules and preferences. Organizations implementing oral health education should consider hybrid models or, at minimum, recognize that single-modality approaches, while more straightforward administratively, may sacrifice effectiveness.

Third, intervention effectiveness varies meaningfully across population subgroups, with important equity implications. Younger adults, higher-educated individuals, and those with existing dental insurance demonstrate larger behavior changes, while lower-literacy populations and uninsured individuals show smaller improvements. These patterns suggest that universal, one-size-fits-all programming may inadvertently widen health disparities if not accompanied by targeted efforts to reach and effectively engage vulnerable populations. Addressing oral health equity requires programmatic attention to literacy-appropriate materials, multi-modal delivery accommodating diverse learning needs and preferences, direct addressing of structural barriers including costs and access, and potentially targeted programming specifically designed for high-need, high-barrier populations.

Fourth, the cost-effectiveness findings provide compelling economic justification for investment in community-based oral health education. At $87 per participant achieving sustained behavior change, averaging across modalities, these programs represent efficient use of public health resources, particularly given that prevented dental disease generates substantial treatment cost savings. From a health systems perspective, investing in prevention reduces future treatment burden and associated costs, potentially enabling reallocation of resources from treating advanced preventable disease to addressing complex conditions requiring specialized care.

Fifth, sustained behavior change requires not just information provision but comprehensive approaches addressing knowledge, motivation, skills, self-efficacy, barriers, social norms, and environmental supports. The interventions in this study, grounded in multiple behavior change theories and incorporating diverse evidence-based strategies, achieved meaningful improvements, whereas previous research suggests that simple information provision typically produces knowledge change but limited behavioral impact. Effective programs must go beyond telling people what to do to help them overcome barriers, build confidence and skills, establish supportive social environments, and create conditions enabling sustained health behaviors.

Looking forward, the convergence of public health education, digital health technologies, and community engagement creates unprecedented opportunities for oral disease prevention. As digital health tools proliferate and become increasingly sophisticated, incorporating artificial intelligence for personalization, gamification for engagement, and social networking for peer support, their potential for behavior change may expand beyond what current evidence demonstrates. However, ensuring equitable benefit requires attention to digital divides, literacy requirements, and the essential value of human connection and in-person skill-building for some populations and contexts.

The policy implications are clear. Oral health, often marginalized within health systems and public health priorities, warrants greater attention and investment given its impacts on overall health, quality of life, and healthcare costs. Community-based prevention programs represent one important component of comprehensive oral health strategies, complementing clinical preventive services, policy interventions addressing social determinants of health, and initiatives expanding access to dental care. Effective policy approaches require multi-level interventions addressing individual behavior, healthcare systems, community environments, and structural barriers simultaneously.

Ultimately, achieving meaningful reductions in oral disease burden and oral health disparities requires sustained commitment to prevention from policymakers, health systems, community organizations, dental professionals, and individuals. This research demonstrates that community-based education represents an effective, cost-effective tool for prevention, warranting inclusion in comprehensive oral health strategies alongside other evidence-based interventions.

7. Limitations

While this research provides valuable evidence regarding community-based oral health education effectiveness, several limitations warrant acknowledgment and inform interpretation of findings.

7.1 Study Design Limitations

The quasi-experimental design with matched comparison groups, while representing a rigorous approach for community-based intervention research, does not eliminate all potential confounding. Participants self-selected into intervention programs (though unaware of specific study hypotheses), potentially introducing selection bias if individuals choosing to participate differ systematically from non-participants in unmeasured ways affecting outcomes. While intervention and comparison groups were well-matched on measured demographic, socioeconomic, and baseline behavioral characteristics, unmeasured differences in motivation, health consciousness, or social support may exist. True randomization would have provided stronger causal inference but proved infeasible given practical and ethical constraints of community-based programming.

Related to selection bias, the requirement that comparison participants consent to assessment-only participation may have selected a particularly motivated or health-conscious comparison group, potentially biasing toward underestimating intervention effects. However, the baseline comparability across groups and the reasonable baseline behavior patterns similar to national surveillance data suggest this bias, if present, is likely modest.

7.2 Measurement and Outcome Assessment Limitations

Primary behavioral outcomes relied substantially on self-report, introducing potential social desirability bias where participants may over-report desirable behaviors or under-report problematic behaviors, particularly if they perceive that accurate reporting might disappoint program staff or affect their evaluation. Several features of the study design mitigate this concern: behavioral surveys emphasized that responses would remain confidential and would not affect program participation or evaluation; the correspondence between self-reported behaviors and clinical outcomes provides validity evidence; and comparison participants, who might have less motivation for socially desirable responding, showed patterns consistent with population norms, suggesting limited social desirability effects.

Nonetheless, more objective behavioral measurement would strengthen confidence in findings. Technologies such as smart toothbrushes with usage tracking, video observation, or real-time ecological momentary assessment could provide more objective data but introduce substantial costs, logistics challenges, and privacy concerns limiting feasibility for large samples. Future research might employ these intensive measurement approaches with sub-samples while using self-report for the full sample.

The 12-month follow-up, while longer than most oral health education studies, remains relatively short-term for assessing truly sustained behavior change and clinical disease outcomes. Behaviors and clinical indicators showed favorable trajectories from 6 to 12 months, suggesting stability, but whether improvements persist for multiple years requires extended follow-up. Similarly, while improved plaque control and reduced gingivitis suggest reduced risk for caries and periodontitis, observing actual disease incidence requires multi-year longitudinal assessment. Plans for extended follow-up at 24 and 36 months with a participant subset will address this limitation partially.

7.3 Sample and Generalizability Limitations

Despite efforts to recruit diverse participants across varied settings, the sample may not fully represent all U.S. adults. The requirement for English proficiency excluded non-English speakers, a significant limitation given that limited English proficiency associates with oral health disparities and represents an important target population. Multi-lingual programming would address this limitation and likely demonstrate effectiveness given that barriers addressed (knowledge, motivation, skills) transcend language, though culturally appropriate adaptations would be essential.

The sample included few adults over age 65, as recruitment focused on working-age adults in employment and community settings. Older adults represent an important population experiencing substantial oral disease burden, particularly periodontal disease and tooth loss, and may respond differently to educational interventions given different life circumstances, health priorities, and potentially different technology comfort. Dedicated research examining oral health education effectiveness among older adults is warranted.

Geographic representation, while including six states across different U.S. regions, remains limited. State-level differences in oral health outcomes, dental insurance regulation, Medicaid dental coverage, dental workforce availability, and water fluoridation might affect program effectiveness. The study sites were predominantly in metropolitan or micropolitan areas; extremely rural areas with severe geographic access barriers were underrepresented. Effectiveness might differ in frontier rural areas where dental access is most limited.

7.4 Intervention Implementation Variation

Despite standardized intervention protocols and training, implementation varied across sites due to local adaptation, educator differences, participant characteristics, and organizational contexts. This real-world variation enhances generalizability (findings reflect programs as actually implemented, not just idealized protocols) but introduces noise and makes isolating specific active ingredients difficult. More controlled efficacy trials could identify which program components are essential versus optional, informing streamlined, optimized programming. However, community-based effectiveness research necessarily accepts implementation variation as reflecting real-world conditions.

Engagement levels varied substantially both across and within intervention modalities. While average engagement was reasonable, some participants attended few sessions or rarely accessed digital platforms but remained in the study and were included in analyses, potentially diluting effect size estimates. Per-protocol analyses examining outcomes among high-engagement participants showed stronger effects, but such analyses risk selection bias (high-engagement participants may differ systematically from low-engagement participants). Understanding engagement barriers and facilitators represents an important research direction.

7.5 Statistical and Analytical Limitations

Multiple statistical tests were conducted examining various outcomes, subgroups, and moderators, increasing Type I error risk despite Bonferroni correction for primary outcomes. While most key findings remained significant after stringent correction, some secondary findings might represent chance associations given multiple comparisons. Replication in independent samples would strengthen confidence.

The moderator analyses, while providing important insights about differential effectiveness across subgroups, involved numerous statistical tests of two-way and three-way interactions. These analyses should be considered exploratory and hypothesis-generating rather than definitive. Additionally, power for detecting moderation effects was limited for small subgroups, potentially missing important differences or producing unstable effect estimates.

Missing data due to participant attrition (22% by 12-month follow-up) introduces potential bias. While multiple imputation and sensitivity analyses suggested that conclusions were robust to missing data assumptions, if participants who discontinued participation differed systematically from completers in unmeasured ways affecting outcomes (missing not at random), findings could be biased. The similar attrition rates across intervention and comparison groups reduce concerns about differential attrition bias, though absolute attrition remains a limitation.

7.6 External Validity and Context-Specific Considerations

The study was conducted within specific organizational and community contexts that may not generalize universally. Intervention sites were organizations with existing commitment to health promotion and infrastructure supporting program delivery. Effectiveness might differ in settings with less organizational capacity, competing priorities, or limited resources. Additionally, all intervention sites were in communities with at least minimal dental service availability; effectiveness might differ in dental deserts where improved knowledge and motivation cannot translate into dental visits due to absent providers.

The interventions were delivered as discrete, time-limited programs rather than ongoing services integrated into community organizations' routine programming. Sustainability and sustained effectiveness when programs transition from externally-funded evaluation to organization-sustained programming remain uncertain. The transition from researcher-supported implementation to routine practice often results in effectiveness decline (the efficacy-effectiveness gap), suggesting that real-world outcomes might be somewhat smaller than research-supported findings.

8. Practical Implications

The research findings yield numerous practical implications for organizations, practitioners, policymakers, and researchers working to improve oral health through community-based education.

8.1 For Public Health Departments and Community Organizations

Public health departments and community-based organizations implementing oral health education programs can leverage several key findings:

Invest in Hybrid Program Models: The demonstrated superiority of hybrid approaches suggests that combining in-person and digital components optimizes effectiveness. Organizations should consider hybrid models as the preferred approach when resources permit. Implementation might involve core in-person workshops for foundational education and skill-building,

complemented by digital platforms providing ongoing reinforcement, tracking, and support. This approach maximizes effectiveness while maintaining cost-efficiency and scalability.

Prioritize High-Need Populations with Tailored Approaches: Given moderating effects of education, literacy, and insurance status, organizations should prioritize outreach to vulnerable populations while recognizing that "one-size-fits-all" programming may be less effective for these groups. Tailored programming for lower-literacy populations should emphasize visual aids, demonstration, interactive activities, and in-person components over text-heavy digital content. Programs for uninsured populations should proactively address financial barriers, connecting participants to safety-net dental clinics, dental schools, free dental days, and financial assistance programs.

Emphasize Self-Efficacy Building: Given the mediating role of self-efficacy, programs should prioritize building participants' confidence through skill demonstration, hands-on practice with feedback, problem-solving around barriers, and graduated success experiences. Simply providing information about what to do is insufficient; participants need opportunities to practice skills and experience success building confidence.

Ensure Adequate Intensity and Duration: The programs in this study involved 6-12 weeks of engagement with multiple touchpoints. Organizations should resist pressure to deliver overly brief, one-shot programming. While brief interventions provide value, meaningful behavior change typically requires repeated exposure, skill development time, and ongoing reinforcement. Programs should be designed for adequate intensity (multiple sessions or regular digital engagement) and extended duration.

Develop Systematic Engagement Strategies: Given strong correlations between engagement and outcomes, programs must actively work to maintain participation. Effective strategies include personal outreach and reminders (text messages, phone calls), convenient scheduling accommodating work and family responsibilities, addressing logistics barriers (childcare, transportation, technology access), meaningful incentives (not necessarily expensive but personally valued), and creating social connections and peer support making participation rewarding.

8.2 For Dental Professionals and Healthcare Providers

Dentists, dental hygienists, primary care physicians, and other healthcare providers can support and complement community-based oral health education:

Refer Patients to Community Programs: Providers should familiarize themselves with community-based oral health education programs in their service areas and actively refer patients, particularly those demonstrating knowledge gaps, suboptimal oral hygiene, or barriers to implementing recommended practices. Referral should be warm (making personal connections) rather than passive (simply mentioning programs exist).

Reinforce Key Messages: Providers can enhance effectiveness by reinforcing messages from community programs during clinical encounters. Brief chairside education reviewing proper brushing and flossing technique, discussing nutrition's role in oral health, and encouraging preventive visits complements and reinforces community education.

Address Financial and Access Barriers: For patients expressing motivation to improve oral health behaviors or seek preventive care but citing financial barriers, providers should proactively offer solutions: information about payment plans, sliding fee scales, community health center dental clinics, dental school clinics, and public programs. Simply recommending behaviors without addressing stated barriers creates frustration and reduces credibility.

Recognize Limits of Individual Education: While supporting education, providers should recognize that some patients' suboptimal oral health behaviors reflect structural barriers (poverty, lack of insurance, limited health literacy, competing priorities) rather than simple knowledge deficits. Clinical approaches should combine education with motivational interviewing, harm reduction strategies, and advocacy for policy solutions addressing social determinants of oral health.

8.3 For Health Educators and Program Implementers

Health educators designing and delivering community-based oral health programs should incorporate several evidence-based principles:

Apply Behavior Change Theory Deliberately: Effective programs ground activities in behavior change theory. Specifically, programs should address Health Belief Model constructs (perceived susceptibility and severity, benefits and barriers, self-efficacy) through education about disease risk, emphasizing personal relevance, highlighting benefits, addressing specific

barriers through problem-solving, and building confidence through skill practice. Social Cognitive Theory principles (self-efficacy, outcome expectations, modeling) should guide program design including demonstration by credible models, vicarious learning opportunities, and creating positive outcome expectations.

Use Interactive, Participatory Methods: Adult learning principles emphasize active engagement over passive information reception. Programs should minimize lecture-style content delivery in favor of interactive discussions, small group activities, skill practice with feedback, problem-solving exercises, and participant-driven goal-setting. Adults learn best when they actively construct knowledge rather than passively receiving information.

Provide Concrete Skills and Tools: Beyond education, participants need concrete skills for behavior implementation. Proper brushing and flossing techniques should be demonstrated and practiced, not just described. Participants should receive oral hygiene supplies (toothbrushes, floss) enabling immediate implementation. Dietitians or nutritionists might provide practical strategies for reducing sugar consumption through meal planning, healthy substitutions, and grocery shopping guidance.

Create Supportive Community: Particularly for in-person programs, creating peer support and community connection enhances outcomes. Participants should have opportunities to share experiences, problem-solve collectively, provide mutual encouragement, and build relationships extending beyond formal program sessions. Online community forums can serve similar functions for digital programs, though they require active moderation to maintain engagement and supportive tone.

8.4 For Policy Makers and Health System Leaders

Findings support several policy directions for improving oral health through prevention:

Invest in Community-Based Prevention: The demonstrated effectiveness and cost-effectiveness of community-based oral health education support public funding for these programs as part of comprehensive oral health strategies. State and local health departments should include oral health education in health promotion programming, with adequate dedicated funding. The approximately $100 per-participant cost for effective programs represents modest investment relative to treatment costs for preventable dental disease.

Expand Dental Coverage: While education improves knowledge, attitudes, and oral hygiene behaviors, dental visit improvements are limited by financial barriers for uninsured individuals. The finding that insurance status moderated dental visit outcomes underscores that prevention education must be complemented by accessible, affordable dental care. Policy priorities should include Medicaid adult dental benefit expansion, subsidized insurance for low-income working adults, and safety-net clinic capacity building.

Support Digital Health Infrastructure: Given digital interventions' effectiveness, scalability, and cost-efficiency, health systems should invest in digital health infrastructure including mobile health platforms, telehealth capabilities, and patient portals with health education content. However, ensuring equity requires parallel attention to broadband access and digital literacy, particularly in rural areas and low-income communities.

Integrate Oral Health into Primary Care:** Oral health remains siloed from general healthcare despite strong oral-systemic health connections. Policies promoting medical-dental integration including primary care provider training on oral health screening and education, co-location of dental and medical services, and payment models incentivizing integrated care could extend preventive education reach to patients not regularly accessing dental care.

Require Oral Health Education in Schools: While this study focused on adults, establishing oral health knowledge and habits early provides lifelong benefits. States should mandate age-appropriate oral health education in K-12 curricula, creating population-level health literacy and normalizing preventive behaviors. Adult programs then reinforce rather than establish health knowledge.

8.5 For Researchers and Evaluators

The research identifies several priorities for future investigation:

Conduct Long-Term Follow-Up Studies: Extending follow-up to 24, 36, and 60 months would assess whether behavior changes persist long-term and translate into reduced disease incidence (caries, periodontitis progression, tooth loss). Understanding maintenance predictors would inform program enhancements supporting sustained behavior change.

Develop and Test Targeted Interventions for High-Risk Populations: Given effectiveness variations across subgroups, developing interventions specifically designed for vulnerable populations (low-literacy, uninsured, racial/ethnic minorities experiencing disparities) represents an important priority. Targeted programs incorporating cultural tailoring, addressing specific barriers, and partnering with trusted community organizations may achieve more equitable outcomes than universal programming.

Investigate Active Program Components: Dismantling studies systematically varying program components (e.g., comparing programs with vs. without skill practice, with vs. without peer support) would identify essential elements versus optional enhancements, enabling streamlined, efficient programming. Such studies require adequate power and factorial designs testing multiple components simultaneously.

Examine Implementation Science Questions: Understanding how to translate evidence-based programs from controlled research to routine community practice represents a critical gap. Implementation research should examine: organizational factors facilitating or impeding adoption; training and technical assistance needs for community organizations; adaptations made during real-world implementation and their effects on outcomes; and strategies for sustaining programs after initial funding ends.

Evaluate Emerging Technologies: As digital health tools evolve incorporating artificial intelligence for personalization, augmented reality for skill training, wearable sensors for behavior monitoring, and blockchain for incentive systems ongoing evaluation of their effectiveness, optimal design features, and equity implications remains essential. Technology evaluation should include not just efficacy but also engagement, acceptability, and implementation feasibility.

9. Future Research

While this study advances understanding of community-based oral health education effectiveness, numerous important questions remain for future investigation.

9.1 Long-Term Outcomes and Disease Prevention

Extending follow-up beyond 12 months is crucial for understanding sustained behavior change and clinical disease outcomes. Key research questions include:

Multi-Year Behavior Maintenance: Do behavioral improvements observed at 12 months persist at 24, 36, and 60 months? What proportion of participants maintain improvements versus regressing to baseline behaviors? What factors predict long-term maintenance versus regression? Understanding these patterns would inform program design for sustained impact.

Clinical Disease Incidence: Do improved preventive behaviors and clinical indicators (reduced plaque, decreased gingivitis) translate into reduced incidence of dental caries, periodontal disease progression, and tooth loss over time? Longitudinal assessment of disease outcomes would provide definitive evidence regarding programs' ultimate public health value. Such studies require large samples followed for multiple years, representing substantial investment but providing essential evidence.

Systemic Health Impacts: Given oral-systemic health connections, do oral health improvements affect outcomes including cardiovascular events, diabetes control, respiratory infections, and pregnancy outcomes? Examining broader health impacts would strengthen the case for oral health investment and support medical-dental integration.

Booster Interventions: Do periodic booster sessions or ongoing low-intensity interventions (e.g., quarterly text messages, annual brief refresher workshops) enhance long-term maintenance? Comparing time-limited programs to programs with ongoing maintenance support would inform optimal program duration and intensity for sustained impact.

9.2 Targeted Interventions for Vulnerable Populations

Developing and testing interventions specifically designed for populations experiencing oral health disparities represents a priority:

Low-Literacy Tailored Programs: What program characteristics optimize effectiveness for lower-literacy populations? Potential features include: simplified text with lower reading levels, extensive use of visual aids and videos, emphasis on verbal communication and demonstration over written materials, one-on-one or small-group formats allowing individualized pacing, and incorporating teach-back methods ensuring comprehension. Comparative effectiveness trials testing different approaches would identify optimal strategies.

Culturally Adapted Interventions: While this study found minimal racial/ethnic moderation suggesting programs work across groups, developing culturally adapted interventions incorporating cultural health beliefs, using culturally concordant educators and materials, addressing culture-specific barriers, and partnering with trusted community organizations might enhance effectiveness. Systematic comparison of culturally adapted versus standard interventions would assess added value.

Programs for Uninsured Populations: How can programs address the unique challenges faced by uninsured adults, for whom improved motivation and knowledge may not translate to dental visits due to financial barriers? Comprehensive programs might integrate: oral health education with benefits enrollment assistance (connecting eligible individuals to Medicaid or marketplace subsidies), partnerships with safety-net dental clinics ensuring affordable care access, provision of oral hygiene supplies reducing cost barriers to home care, and peer support from individuals who've successfully navigated access barriers.

Rural-Specific Approaches: Rural populations face unique challenges including limited dental provider availability, geographic distances to care, different cultural contexts, and often lower broadband access. Developing programs specifically designed for rural contexts potentially leveraging telehealth, partnering with agricultural extension services or rural health clinics, employing mobile dental units, and addressing unique rural barriers warrants investigation.

9.3 Optimization of Digital Health Interventions

As digital health technology evolves rapidly, ongoing research optimizing digital oral health interventions is essential:

Personalization and Adaptive Interventions: Can machine learning algorithms personalize content, timing, and intensity based on individual user characteristics, behaviors, and engagement patterns? Adaptive interventions adjusting in real-time based on user responses may enhance effectiveness. For example, users demonstrating high engagement might receive more advanced content while those showing declining engagement receive motivational boosters or alternative content formats.

Gamification and Behavioral Economics: What role can gamification elements (points, badges, leaderboards, challenges) play in sustaining engagement and motivation? How can behavioral economics principles (loss aversion, commitment contracts, social competition) be incorporated ethically to enhance effectiveness? Systematic testing of these approaches would identify effective strategies while avoiding manipulative or coercive elements.

Social Features and Peer Support: What online community features optimize peer support and social learning while avoiding negative dynamics (misinformation, competition undermining rather than supporting behavior change)? Comparing digital interventions with varying social features would assess their value-added. Related questions concern optimal moderation strategies balancing community autonomy with content quality assurance.

Technology Delivery Platforms: As technology platforms proliferate, understanding optimal delivery channels is important. Should programs be delivered via dedicated mobile applications, SMS/text messaging, social media platforms, wearable device integration, or multi-channel approaches? Platform choice affects reach, engagement, cost, and effectiveness in ways that warrant empirical comparison.

Conversational AI and Chatbots: Could AI-powered chatbots providing personalized education, answering questions, and delivering motivational interviewing enhance accessibility while reducing costs? Early evidence from other health domains suggests promise but evaluation specific to oral health is needed, particularly regarding acceptability and effectiveness compared to human-delivered education.

9.4 Mechanistic and Mediator Research

Understanding mechanisms through which interventions produce effects would inform program optimization:

Mediation Analysis: What are the primary mechanisms through which interventions change behavior? Is it primarily through improved knowledge, enhanced self-efficacy, reduced perceived barriers, established implementation intentions, social support, or environmental restructuring? Formal mediation analyses testing these pathways would identify most important mediators, suggesting where program resources should be concentrated.

Behavior Change Techniques: Community-based programs typically employ multiple behavior change techniques simultaneously. Component analysis or factorial trials systematically varying techniques (e.g., goal-setting vs. no goal-setting, self-monitoring vs. no self-monitoring, providing supplies vs. not providing supplies) would identify which techniques are essential versus which provide marginal benefit, enabling streamlined, efficient programs.

Habit Formation: Oral hygiene behaviors, when established, become habitual and relatively automatic. Understanding how programs can facilitate habit formation through consistent contexts, repetition, environmental cues, and implementation intentions would enhance sustained behavior change. Research might examine optimal frequency and duration of program contact for habit establishment.

Social Influences: How do social network characteristics, peer norms, and household member behaviors affect intervention effectiveness? Understanding social influences would inform whether programs should target individuals versus households/social networks, how to leverage positive social influences, and how to address adverse social environments (e.g., households where no one practices good oral hygiene).

9.5 Implementation Science Research

Translating evidence-based programs into routine practice requires implementation science:

Adoption and Reach: What factors facilitate or impede community organizations' adoption of evidence-based oral health education programs? How can programs be designed and packaged to enhance adoption? What technical assistance or implementation support do organizations need? Understanding adoption barriers and facilitators would accelerate evidence-based program dissemination.

Adaptation and Fidelity: What program adaptations do organizations make during implementation, and how do adaptations affect outcomes? Identifying a core set of essential elements requiring fidelity versus adaptable components allowing tailoring would provide flexibility while maintaining effectiveness. Systematic documentation and evaluation of real-world adaptations would inform this.

Sustainability: How can programs be sustained after initial funding ends? What organizational characteristics, funding mechanisms, partnership models, and program features support sustainability? Following programs over time and comparing sustained versus discontinued programs would identify sustainability predictors.

Scale-Up Strategies: What strategies effectively scale evidence-based programs from pilot demonstrations to widespread implementation? Comparing different scale-up approaches (e.g., training existing community health workers, developing train-the-trainer models, creating online training platforms, establishing centers of excellence) would identify effective strategies for different contexts.

9.6 Economic Evaluations

More sophisticated economic analyses would strengthen the business case for oral health education:

Healthcare Cost Offset Analysis: Comprehensive assessment of healthcare cost impacts should examine not just prevented dental treatment costs but also reduced emergency department visits for dental conditions, effects on chronic disease management costs (through oral-systemic health connections), and productivity impacts (reduced work loss days, improved worker productivity). Such analyses require linkage to medical claims and employment data over extended time periods.

Budget Impact Analysis: While cost-effectiveness analysis compares costs to outcomes, budget impact analysis assesses the financial implications of adopting programs within real-world budget constraints. Budget impact models would help health departments and insurers understand near-term financial implications of program adoption, informing implementation decisions.

Distributional Cost-Effectiveness Analysis: Standard cost-effectiveness analysis treats health gains equally regardless of who experiences them. Distributional analysis assigns additional value to health improvements among disadvantaged populations, aligning with equity objectives. Such analysis would assess whether investing in oral health education targeting vulnerable populations represents good value even if per-person costs are higher or effects are smaller than universal programs.

9.7 Comparative Effectiveness Research

Comparing oral health education to alternative interventions would inform resource allocation:

Education Versus Policy Interventions: How does community-based education compare in effectiveness and cost-effectiveness to policy interventions such as sugar-sweetened beverage taxes, Medicaid dental benefit expansion, school-based sealant programs, or community water fluoridation? Multi-intervention comparison would inform balanced public health strategies combining multiple evidence-based approaches.

Education Versus Behavioral Incentives: How does education compare to direct behavioral incentives (e.g., paying individuals for verified oral hygiene behaviors, insurance premium discounts for dental visits, incentive-based appointment reminder systems)? Understanding relative and combined effectiveness would inform program design.

Population-Level Versus Targeted Approaches: Does targeting programs to high-risk populations (e.g., those with existing periodontal disease, diabetics, pregnant women) produce better population-level outcomes than universal programming, given limited resources? Comparing strategies would inform screening and targeting decisions.

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