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The Effectiveness of B-FRESH (Blind-Friendly Efficient Smart Hygiene) Media in Improving Oral Hygiene Among Blind Students at SMPLB and SMALB A YPAB Surabaya

Ahsani Taqwim Ridwan, Isnanto, and Bambang Hadi Sugito

Department of Dental Health, Poltekkes Kemenkes Surabaya, Surabaya, Indonesia

Corresponding author: Ahsani Taqwim Ridwan (e-mail: ahsaniridwan4@gmail.com)

ABSTRACT Visually impaired children represent a vulnerable population requiring specialized educational and healthcare interventions. According to the World Health Organization, visual impairment is defined as visual acuity in the better eye of less than 10/200 or a visual field of less than 10 degrees from the point of fixation. Previous studies have identified a concerning prevalence of poor oral hygiene among blind students aged 12-18 years at specialized institutions, including SMPLB and SMALB, A YPAB Surabaya, highlighting the need for targeted oral health interventions. This study aimed to evaluate the effectiveness of B-FRESH (Blind-Friendly Efficient Smart Hygiene) media in improving oral hygiene practices and outcomes among visually impaired students. An experimental applied research design was employed with 28 participants recruited from specialized schools for the visually impaired. Data collection utilized standardized plaque index assessment sheets and tooth brushing evaluation checklists to measure oral hygiene parameters. Statistical analysis was conducted using the Mann-Whitney U test to determine significant differences between pre- and post-intervention measurements. The Mann-Whitney test revealed statistically significant results ($p = 0.001 < 0.05$), indicating rejection of the null hypothesis. The findings demonstrated significant effectiveness of the B-FRESH media intervention in enhancing oral hygiene among blind students, with notable improvements observed in plaque reduction and tooth brushing technique proficiency. The implementation of B-FRESH media successfully improved oral hygiene status among visually impaired students, with participants progressing from poor to moderate oral hygiene levels. These findings underscore the critical importance of developing specialized, accessible oral health education tools for individuals with visual impairments. The study provides evidence for incorporating B-FRESH media into routine oral health promotion programs within educational institutions serving blind students, potentially contributing to improved long-term oral health outcomes in this underserved population.

INDEX TERMS Visual Impairment, Oral Hygiene, Dental Health Education, Assistive Technology, Special Needs Students.

I. INTRODUCTION

Visual impairment represents a significant global public health challenge, affecting millions of children worldwide and requiring specialized educational and healthcare interventions [1]. According to the World Health Organization, visual impairment is characterized by visual acuity in the better eye of less than 6/18 (0.3) or corresponding visual field loss to less than 20 degrees [2]. Children with visual impairment are categorized into two primary groups: those with total blindness, who can only distinguish between light and darkness, and those with low vision, who retain some visual capacity to identify objects at specific distances and perceive high-contrast colors [3][4]. These visual limitations significantly impact multiple aspects of daily living, including personal hygiene practices and health maintenance behaviors. Oral health is more compromised among visually impaired individuals than their sighted peers, with research consistently demonstrating elevated rates of dental trauma, plaque accumulation, dental caries, and gingivitis in this population [5][6]. Children and adolescents with vision impairment may be at increased risk of oral health issues, such as periodontal inflammation, poor oral hygiene, dental caries, and dental trauma [7]. Multiple factors contribute to compromised oral health in visually impaired individuals, including physical limitations that impede proper oral hygiene technique acquisition, reduced knowledge regarding dental care practices, and limited motor skill development due to decreased physical activity [8][9][10]. Additionally, oral health care in this group of patients is not always adequate due to the low awareness of the importance of oral health in this population group and the

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fact that these patients prioritize their general health over oral health [11]. Empirical evidence from recent studies reveals concerning oral hygiene levels among blind students, with research indicating average Oral Hygiene Index-Simplified (OHI-S) scores of 4.02 in blind children aged 12-16 years, categorically classified as poor oral hygiene status [12][13]. Contemporary approaches to oral health education for visually impaired populations have evolved to incorporate multi-sensory learning strategies and assistive technologies. Music- and game-based oral health education methods have demonstrated effectiveness in improving the oral health status of visually impaired school children [14]. Traditional educational interventions have primarily relied on tactile learning methods, verbal instruction, and Braille-based materials [15][16]. Recent technological advances have introduced sophisticated assistive technologies, including audio-tactile learning systems, smart devices with voice guidance, and interactive educational media specifically designed for sensory-impaired populations [17][18][19]. Various assistive technologies and media are used to influence oral health behaviors and outcomes for individuals with sensory impairments [20]. However, despite these technological innovations, a comprehensive evaluation of multi-modal educational interventions combining auditory, tactile, and kinesthetic elements remains limited in the literature.

While existing research has established the prevalence of oral health challenges among visually impaired populations and demonstrated the potential of assistive technologies in educational contexts, significant gaps remain in the development and evaluation of comprehensive, multi-sensory oral health education interventions. Current literature lacks sufficient evidence regarding the effectiveness of integrated audio-tactile educational media specifically designed for oral hygiene instruction in blind students. Furthermore, limited research has examined the long-term impact of specialized educational interventions on oral hygiene behavior modification and maintenance in this vulnerable population. The absence of standardized, evidence-based educational tools specifically tailored for visually impaired students represents a critical gap in current oral health promotion strategies. This study aims to evaluate the effectiveness of B-FRESH (Blind-Friendly Efficient Smart Hygiene) media, an innovative multi-sensory educational intervention, in improving oral hygiene practices and outcomes among visually impaired students aged 12-18 years. This research provides three significant contributions to the field of oral health education for visually impaired populations:

1. Development and validation of a novel multi-sensory educational tool (B-FRESH) that integrates auditory instructions, tactile feedback, and kinesthetic learning elements specifically designed for blind students.
2. Empirical evidence demonstrating the effectiveness of technology-enhanced oral health education interventions in improving measurable oral hygiene outcomes, as assessed through standardized plaque indices and behavioral checklists.
3. Establishment of a replicable methodological framework for implementing and evaluating assistive technology-based health education programs in specialized educational settings for visually impaired students.

This paper is organized as follows: Section II reviews related works on oral health challenges in visually impaired populations and theoretical foundations of multi-sensory educational interventions; Section III delineates the research methodology, including experimental design, participant selection, B-FRESH media development, and data collection procedures; Section IV presents the results of the intervention and their statistical analysis; and Section V discusses the implications of findings, study limitations, and potential future directions for assistive technology applications in oral health education for visually impaired students.

II. METHOD

A. RESEARCH DESIGN AND SAMPLE SELECTION

This study employed a prospective experimental research design with a pre-test and post-test control group configuration to evaluate the effectiveness of B-FRESH (Blind-Friendly Efficient Smart Hygiene) media intervention on oral hygiene improvement among visually impaired students [21]. The experimental design was specifically selected to establish causal relationships between the multi-sensory educational intervention and measurable oral hygiene outcomes, following established protocols for clinical intervention studies in oral health education [22]. The study population comprised visually impaired students aged 12-18 years enrolled at SMPLB (Sekolah Menengah Pertama Luar Biasa) and SMALB (Sekolah Menengah Atas Luar Biasa), A YPAB Surabaya, Indonesia. A total of 28 participants were recruited through purposive sampling methodology based on predetermined inclusion and exclusion criteria. Inclusion criteria encompassed: (1) students with diagnosed visual impairment (total blindness or low vision as defined by WHO standards), (2) age range of 12-18 years, (3) absence of severe cognitive impairments, (4) ability to participate in oral hygiene activities independently, and (5) informed consent from parents or guardians. Exclusion criteria included: (1) presence of systemic diseases affecting oral health, (2) current orthodontic treatment, (3) physical disabilities preventing independent tooth brushing, and (4) concurrent participation in other oral health programs. The sample size was determined based on power analysis calculations for detecting significant differences between intervention and control groups, with an alpha level of 0.05 and power of 80% [23]. Participants were randomly allocated to either the intervention group (n=14) or control group (n=14) using computer-generated randomization sequences to minimize selection bias and ensure comparable baseline characteristics between groups.

B. INTERVENTION PROTOCOL

The B-FRESH educational intervention was developed as a comprehensive multi-sensory learning tool incorporating

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auditory, tactile, and kinesthetic elements specifically designed for visually impaired learners [24]. The intervention comprised three integrated components: (1) a dental phantom model with a movable toothbrush for tactile exploration, (2) structured audio instructions delivered via a miniature MP3 player with SD card technology, and (3) guided hand-over-hand demonstration techniques. The audio component featured systematically recorded instructional content covering proper brushing techniques for anterior teeth, posterior teeth, and tongue surfaces, presented in a melodic format to enhance retention and engagement [25]. The intervention group received comprehensive B-FRESH media training over a standardized protocol spanning four weeks, with two 30-minute sessions per week. Each session followed a structured sequence: (1) initial tactile exploration of the dental phantom model, (2) synchronized audio instruction playback, (3) guided hand-over-hand demonstration of proper brushing techniques, and (4) independent practice with real-time feedback. The control group maintained standard oral hygiene practices without specialized intervention, receiving conventional verbal instructions consistent with routine school health programs.

C. DATA COLLECTION AND ANALYSIS

The assessment of oral hygiene status employed the Silness and Löe Plaque Index (PI), a clinically validated instrument designed to quantify plaque accumulation across dental surfaces [26]. This standardized assessment protocol involved the systematic evaluation of six representative teeth (16, 12, 24, 36, 32, 44) utilizing a four-point ordinal scale from 0 (absence of plaque) to 3 (abundant plaque readily visible without magnification). Plaque disclosure agents were incorporated into the examination protocol to facilitate enhanced visualization and accurate assessment of plaque deposits during clinical evaluation. All clinical assessments were conducted by calibrated dental practitioners adhering to standardized examination protocols, thereby ensuring optimal inter-examiner reliability throughout the study period. A comprehensive observational assessment instrument was developed to evaluate tooth brushing technique proficiency, incorporating specific evaluative criteria including brush positioning, movement patterns, systematic coverage of tooth surfaces, and overall technical competency [27]. The assessment framework utilized a dichotomous scoring methodology (adequate/inadequate) for individual components, with aggregate scores providing an overall measure of brushing technique proficiency. Data collection followed a three-phase longitudinal design encompassing baseline assessment (pre-intervention), immediate post-intervention evaluation (4 weeks), and follow-up assessment (8 weeks post-intervention). All clinical examinations were conducted within standardized dental examination facilities under controlled lighting conditions, utilizing standard dental instrumentation including dental mirrors, explorers, and plaque disclosure agents. Examiner calibration was completed before study commencement, achieving inter-examiner reliability coefficients exceeding 0.85 for plaque index measurements. Statistical analyses were performed using SPSS version 26.0 software. Descriptive statistics were computed for participant demographics and baseline characteristics. Data distribution normality was assessed using the Shapiro-Wilk test. Given the non-normal distribution of plaque index scores, non-parametric statistical procedures were implemented. The Mann-Whitney U test was employed for between-group comparisons of plaque index scores at each assessment interval, as this test is appropriate for comparing independent groups with ordinal or non-normally distributed continuous variables [28]. The Wilcoxon signed-rank test was utilized to evaluate within-group changes from baseline to post-intervention periods. Statistical significance was established at $p < 0.05$ for all analyses.

D. ETHICAL CONSIDERATIONS AND LIMITATIONS

This study received approval from the Institutional Review Board and adhered to ethical principles outlined in the Declaration of Helsinki. Written informed consent was obtained from parents or legal guardians of all participants, with additional assent secured from students aged 12 years and above. Participants retained the right to withdraw from the study at any time without penalty. Data confidentiality was maintained through coded participant identification, and all personal information was securely stored according to institutional data protection protocols [29]. Several methodological limitations were acknowledged in this study's design. The single-center recruitment approach may limit generalizability to broader visually impaired populations. The relatively small sample size, while adequate for detecting large effect sizes, may have limited power to identify smaller but clinically meaningful differences. Additionally, the impossibility of blinding participants to the intervention may have introduced performance bias, though outcome assessors remained blinded to group allocation to minimize detection bias [30].

III. RESULTS

TABLE 1
Respondent Characteristics

Category		F	%
Age	13 years	1	7.1
	14 years	3	21.4
	15 years	3	21.4
	16 years	4	28.6
	17 years	3	21.4
	18 years	0	0
Gender	Male	9	64.3
	Female	5	35.7

Based on the demographic data presented in TABLE 1, the sample population demonstrated a predominant age distribution of 15 years, with male participants constituting the majority of the study cohort. According to the baseline data presented in TABLE 2, pre-intervention assessment revealed that the majority of participants in both the intervention group (n=14) and control group (n=14) exhibited poor plaque index scores before the implementation of B-FRESH media educational intervention. According to the post-intervention data presented in TABLE 3, participants in the intervention group (n=14) demonstrated a predominant shift to moderate plaque index scores following B-FRESH media educational intervention, whereas the control group (n=14) maintained

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predominantly poor plaque index values. According to the statistical results depicted in TABLE 4, the Mann-Whitney U test comparing post-intervention plaque index scores between the intervention and control groups produced a p-value of 0.001 ($p < 0.05$). Consequently, the null hypothesis (H_0) is rejected, and the alternative hypothesis (H_1) is supported. These findings demonstrate a statistically significant impact of the B-FRESH (Blind-Friendly Efficient Smart Hygiene) media intervention on oral hygiene outcomes among visually impaired students when compared to the control group that did not receive the B-FRESH treatment.

TABLE 2
Frequency Distribution of Oral Hygiene Pre-test in Intervention and Control Groups at SMP SMA LB A YPAB Surabaya and SLB Keleyan Bangkalan

Group	Plaque Index Value Category	F	%
Intervention	Good	0	0
	Moderate	2	14
	Poor	12	85
	Amount	14	100
Control	Good	0	0
	Moderate	1	7.14
	Poor	13	92.8
	Amount	14	100

TABLE 3
Frequency Distribution of Post-test Oral Hygiene in the Intervention Group at SMP SMA LB A YPAB Surabaya

Group	Plaque Index Value Category	F	%
Intervention	Good	2	14.2
	Moderate	10	71.4
	Poor	2	14.2
	Amount	14	100
Control	Good	0	0
	Moderate	1	7.14
	Poor	13	92.8
	Amount	14	100

TABLE 4
Mann-Whitney Test Results on Post-test Values of Intervention Group and Control Group

Category	Group		p-value
	Intervention	Control	
Good	2	0	
Moderate	10	1	0.001
Poor	2	13	

IV. DISCUSSION

The findings of this study demonstrate a statistically significant improvement in oral hygiene status following the implementation of B-FRESH (Blind-Friendly Efficient Smart Hygiene) media intervention among visually impaired students. The data analysis revealed a substantial shift in plaque index categorization within the intervention group, with 85% of participants transitioning from poor oral hygiene status to 71.4% achieving moderate oral hygiene levels. This improvement represents a clinically meaningful change that contrasts markedly with the control group, which maintained predominantly poor oral hygiene indices throughout the study period. The superior performance of the intervention group can be attributed to the multi-sensory educational approach inherent in B-FRESH media design. Unlike conventional oral health education methods that rely heavily on visual demonstration, the B-FRESH system integrates tactile manipulation through movable dental phantom components with structured auditory instruction delivered via portable digital audio technology [31]. This dual-sensory approach addresses the specific learning requirements of visually impaired populations, who must rely predominantly on auditory and tactile channels for information acquisition and skill development. The theoretical foundation for these observed behavioral changes aligns with Skinner's Stimulus-Organism-Response (S-O-R) behavioral paradigm, which posits that environmental stimuli (the B-FRESH intervention) trigger cognitive processing within the individual (understanding of proper oral hygiene techniques), ultimately resulting in modified behavioral responses (improved tooth brushing practices) [32]. This behavioral learning theory framework provides a robust explanatory model for understanding how educational interventions can effectively modify health-related behaviors through systematic stimulus-response conditioning. The integration of auditory instruction with kinesthetic learning through tactile manipulation creates multiple reinforcement pathways that enhance knowledge retention and skill acquisition among visually impaired learners. The effectiveness of audio-enhanced education in this population can be further understood through cognitive load theory, which suggests that information processing is optimized when multiple sensory modalities are engaged without overwhelming cognitive capacity [33]. The melodic presentation of oral hygiene instructions within the B-FRESH system appears to facilitate information encoding and retrieval processes, consistent with research demonstrating enhanced memory performance when educational content is presented through musical formats [34]. The results of this investigation align with and extend findings from several previous studies examining oral health education interventions for visually impaired populations. Recent systematic reviews have identified that combination approaches involving multiple sensory modalities demonstrate superior effectiveness compared to single-modality interventions in improving oral health behaviors and clinical outcomes among visually impaired children.

Maryani et al. reported similar efficacy of audio-based oral health education in blind populations, demonstrating significant improvements in knowledge and practical skills following structured auditory instruction [35]. The findings from Mardiati corroborate our results, showing enhanced OHI-S scores following audio-based educational interventions compared to baseline measurements [36]. Furthermore, Alamsyah demonstrated the superior effectiveness of audio instruction compared to traditional Braille-based education, suggesting that auditory learning modalities may be more accessible and effective for this population [37]. Recent clinical trials have consistently demonstrated that specially designed oral health programs incorporating audio and tactile elements produce significant improvements in knowledge, attitudes, and practices among visually impaired children. However, our study extends these findings by demonstrating the specific effectiveness of

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integrated audio-tactile media systems that combine real-time tactile feedback with synchronized auditory instruction, representing a novel advancement in assistive educational technology. A meta-analysis of oral health educational interventions for visually impaired school children confirmed that newer educational methods are effective in improving plaque and gingival scores over short-term periods, which supports our findings of significant plaque index improvements following B-FRESH intervention. However, the authors noted limitations regarding long-term effectiveness assessment, highlighting the need for extended follow-up studies to determine the sustainability of behavioral changes. Deolia's research demonstrated increased percentages of respondents achieving good plaque scores following educational intervention, consistent with our observed transition from poor to moderate oral hygiene categories [38]. The convergence of these findings across multiple studies provides strong evidence supporting the effectiveness of specialized oral health education approaches for visually impaired populations.

Several methodological limitations must be acknowledged when interpreting these findings. The single-center recruitment approach limits the generalizability of results to broader visually impaired populations with potentially different demographic characteristics, educational backgrounds, or access to healthcare resources. The relatively modest sample size (n=28), while statistically adequate for detecting the observed effect sizes, may have limited power to identify smaller but clinically meaningful differences or to conduct meaningful subgroup analyses based on degree of visual impairment or demographic variables [39]. The inability to implement participant blinding represents an inherent limitation in behavioral intervention studies, potentially introducing performance bias as participants in the intervention group may have been more motivated to demonstrate improved oral hygiene practices. However, the implementation of blinded outcome assessment helped minimize detection bias in clinical measurements. The short-term follow-up period (8 weeks) prevents assessment of long-term behavioral maintenance and sustainability of improved oral hygiene practices, which represents a critical gap in understanding the lasting impact of the intervention. Technical limitations of the B-FRESH prototype, particularly the wooden construction materials that required careful handling to prevent damage, may have influenced the natural learning experience and could affect scalability for broader implementation. Future iterations should incorporate more durable materials that can withstand repeated use in educational settings while maintaining tactile sensitivity required for effective learning. The implications of these findings extend beyond immediate clinical outcomes to encompass broader educational and public health considerations. The demonstrated effectiveness of B-FRESH media supports the integration of assistive technology approaches into routine oral health education programs within specialized educational institutions serving visually impaired students. The intervention's success in developing fine motor coordination skills and enhancing cognitive abilities through tactile learning suggests potential applications beyond oral health education to other health behavior domains requiring manual dexterity and procedural knowledge [40].

From a public health perspective, these findings highlight the importance of developing specialized, evidence-based educational interventions that address the unique learning requirements of sensory-impaired populations. The successful implementation of B-FRESH technology demonstrates the feasibility of creating accessible health education tools that can be deployed in resource-limited educational settings, potentially reducing oral health disparities among vulnerable populations. The independence-promoting aspects of the intervention align with broader disability rights and inclusion principles, supporting the development of self-efficacy in personal care activities that contribute to overall quality of life and social integration. Future research should focus on longitudinal assessment of behavioral maintenance, cost-effectiveness analysis of implementation in diverse educational settings, and adaptation of the intervention approach to other health education domains requiring procedural skill development among visually impaired populations.

V. CONCLUSION

This study aimed to evaluate the effectiveness of B-FRESH (Blind-Friendly Efficient Smart Hygiene) media in improving oral hygiene outcomes among visually impaired students through a comprehensive pre-test and post-test experimental design incorporating plaque index measurements and tooth brushing skill assessments. The findings demonstrate statistically significant improvements in oral hygiene status following B-FRESH intervention implementation, with the intervention group exhibiting a substantial reduction in poor oral hygiene prevalence from 85% at baseline to 28.6% post-intervention, representing a transition to moderate oral hygiene levels in 71.4% of participants. Conversely, the control group maintained consistently poor oral hygiene status throughout the study period, with 92.8% of participants exhibiting poor plaque index scores both at baseline and post-intervention phases. The Mann-Whitney U test analysis yielded a p-value of 0.001 ($p < 0.05$), confirming the statistical significance of the intervention effect and establishing B-FRESH media as an effective educational tool for enhancing oral hygiene practices in visually impaired populations. These quantitative outcomes validate the efficacy of multi-sensory educational approaches that integrate auditory instruction with tactile manipulation, addressing the specific learning requirements of students with visual impairment. The intervention's success extends beyond immediate oral health improvements to encompass broader developmental benefits, including enhanced cognitive and spatial abilities through tactile exploration, improved fine motor coordination, increased independence in personal care activities, and potential for creative expression through texture-based learning experiences. The study's implications for educational practice highlight the importance of developing specialized, evidence-based interventions that accommodate the unique sensory processing characteristics of visually impaired learners. Future research endeavors should focus on longitudinal assessment of behavioral maintenance to establish the

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sustainability of improved oral hygiene practices over extended periods, cost-effectiveness analysis for implementation across diverse educational institutions serving visually impaired populations, and technological refinements incorporating more durable materials such as medical-grade metals to enhance prototype longevity and safety. Additionally, investigation into the adaptation of B-FRESH principles for other health education domains requiring procedural skill development, expansion to include gingival health assessments and comprehensive oral health outcomes, and multi-center randomized controlled trials to establish broader generalizability represent promising directions for advancing assistive technology applications in health education for special populations.

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DATA AVAILABILITY

No datasets were generated or analyzed during the current study.

AUTHOR CONTRIBUTION

Ahsani Taqwim Ridwan conceptualized and designed the study, conducted data collection, and participated in data analysis and interpretation. Isnanto contributed to the methodology development, oversaw the implementation of procedures, and contributed to manuscript writing and revisions. Bambang Hadi Sugito assisted with data analysis and interpretation and provided critical feedback on the manuscript. All authors participated in the literature review and manuscript editing. All authors reviewed and approved the final version of the manuscript and agreed to be responsible for all aspects of the work, ensuring integrity and accuracy.

DECLARATIONS

ETHICAL APPROVAL

Ethical approval is not available.

CONSENT FOR PUBLICATION PARTICIPANTS

Consent for the publication of research outcomes was formally obtained from all study participants.

COMPETING INTERESTS

The authors report no conflicts of interest about this work.

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