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Original Article

Impact of an Innovative Teledentistry Mobile App on Oral Health Literacy among Visually Impaired and Deaf Adolescents: A 4-Week Randomized Controlled Trial

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ABSTRACT

This study aimed to evaluate the effectiveness of a mobile-based "teledentistry" approach, delivered through the Telesmile application, in improving awareness of oral health issues and hygiene behaviors among blind and deaf individuals residing in Jazan Province, Saudi Arabia. A controlled randomized parallel-group design was applied to 50 blind and 50 deaf students aged 12–18 years, selected at random from specialized schools according to predefined criteria. A novel teledentistry tool, Telesmile, compatible with both the Apple iOS App Store and Google Play Store, was created for this purpose. For the deaf category, customized Arabic sign language oral hygiene videos were produced and uploaded; for the blind category, experts recorded audio-based instructions, which were then incorporated into the app. Blind (n = 25) and deaf (n = 25) participants in Group I were provided standard oral hygiene guidance, whereas Group II (blind n = 25; deaf n = 25) received the Telesmile intervention. Knowledge related to oral health and hygiene was assessed using a 14-item closed-answer questionnaire at baseline (T0). All participants attended training sessions, and Group II received access to the Telesmile application. Four weeks later (T1), the same questionnaire was administered again to compare changes in knowledge across groups. Analysis using the chi-square test showed that baseline (T0) knowledge scores for both blind and deaf students were extremely low, but demonstrated a marked and statistically significant increase after 4 weeks of exposure to the Telesmile tool ($p < 0.001$).The Telesmile platform substantially improved oral hygiene knowledge among visually and hearing-impaired individuals. Audio-based instruction proved particularly useful for blind participants, while video demonstrations effectively enhanced understanding among deaf users.

Keywords: Mobile App, Oral health, Visually impaired, Deaf

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Introduction

Daily oral hygiene behaviors and access to suitable dental care remain crucial for individuals of all ages [1]. In many regions, however, the availability of dental specialists is limited due to long travel distances, inadequate transportation, lack of awareness, geographical isolation, and sociocultural challenges [2, 3]. These disparities between rural and urban dental services highlight the need for "teledentistry," a modern method that supports remote delivery of dental care [4]. Much like telemedicine, teledentistry may involve teleconsultations, remote education, monitoring, or even telesurgical support, typically through either real-time videoconferencing or "store-and-forward" transfer of clinical records for later diagnostic review and treatment planning [5–7].

The American Dental Association (ADA) notes that teledentistry also encompasses mobile health (m-health), which includes health-related communication and instructional resources via mobile devices such as smartphones, tablets, or computers [8]. The Telesmile

platform functions as a bidirectional communication system allowing users to submit their main concern and personal information, upload photos of oral problems, and receive follow-up contact once their case has been evaluated.

Mobile phone–based applications offer significant potential for improving oral health knowledge, as they provide advantages over conventional pamphlets or spoken explanations. These apps enable continuous access to information, integrating animations, videos, and interactive modules that make learning more engaging. They present complex dental concepts in simplified form and generate tailored guidance, reminders, and preventive suggestions according to a user's age, habits, diet, and risk factors. Additionally, they help reinforce routine hygiene practices through consistent notifications and offer extensive educational resources at no cost [9, 10].

The worldwide rates of both visual and auditory disabilities continue to rise. Globally, approximately 45 million individuals are blind or have significant visual impairment, with most residing in low- and middle-income regions, including Saudi Arabia. In the Kingdom, nearly 1 million people are estimated to be visually impaired [11]. Projections indicate that by 2050, around 2.5 billion individuals will experience some form of hearing difficulty, with at least 700 million expected to need rehabilitative services; more than 1 billion young people remain vulnerable to preventable, irreversible hearing loss from unsafe listening habits [12]. Data from the Ministry of Economy and Planning report that the deaf community in Saudi Arabia exceeds 7,20,000 individuals [13]. Comparative investigations assessing periodontal conditions and oral cleanliness among blind children, adolescents, and older adults versus sighted groups consistently show superior oral health among those without visual impairment [14–16]. Numerous publications also indicate that people with hearing disabilities often demonstrate poorer oral hygiene, elevated caries levels, and unmet dental treatment needs [17, 18].

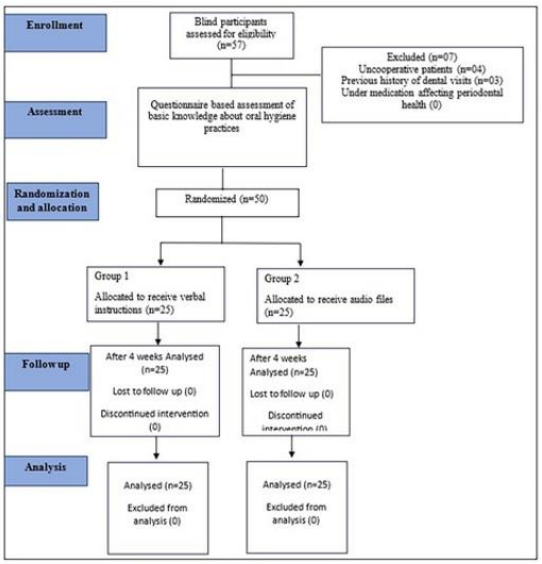
Typically, oral hygiene instruction for persons with disabilities relies heavily on visual tools tailored for their needs [19]. Such training frequently makes use of demonstrations, dental models, and disclosing agents. However, these sessions are generally delivered once and follow a conventional in-person format, limiting their ability to shape lasting daily oral care routines [20]. Moreover, visual teaching materials are ineffective for blind or severely visually impaired learners [21, 22]. These materials also have notable limitations in engaging people with disabilities, reinforcing toothbrushing skills, or maintaining long-term behavioral change [23]. Similarly, individuals with hearing impairments often present with neglected oral hygiene due to communication barriers and persistent societal misconceptions regarding their capabilities [24].

At the same time, there has been a dramatic rise in smartphone ownership and widespread use of mobile applications for various purposes, including medical and dental care [25]. Unfortunately, many communication-focused health apps are designed with the mistaken assumption that most blind or deaf users possess strong literacy skills [26]. In reality, even among the minority of deaf individuals who are literate, many have difficulty understanding professional health terminology [27]. Digital media can, however, provide multiple accessible formats—such as videos, captions, and sign language—to support learning in Deaf and hard-of-hearing populations [28]. For these reasons, the present investigation aimed to evaluate how effectively teledentistry can improve oral health among visually and hearing-impaired individuals. The research was structured to examine the null hypothesis that the Telesmile app would not produce any change in oral health knowledge or oral hygiene practices among blind or deaf users.

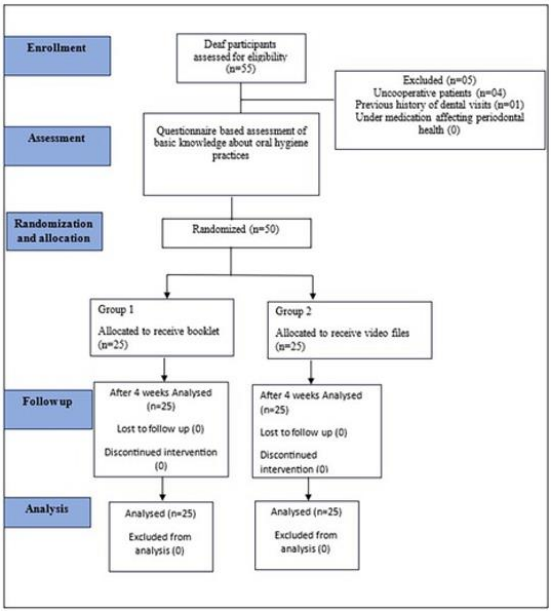
Materials and Methods

Study population

The sample included 50 blind and 50 deaf participants aged 12–18 years, randomly selected from specialized schools for blind and deaf students in Jazan Province, Saudi Arabia. Selection adhered strictly to defined inclusion and exclusion standards. Inclusion requirements were willingness to take part; no professional cleaning within the previous 3 months; and absence of orthodontic bands or removable prostheses. Exclusion criteria included lack of cooperation, use of medications influencing periodontal or gingival conditions, and any history of dental visits. The study followed the CONSORT guidelines for randomized controlled trials. **Figure 1** illustrates the participant progression and intervention allocation.



a)



b)

Figure 1. (a,b) CONSORT flow diagram for blind and deaf groups.

Informed consent and ethical clearance

The study objectives were clearly explained to participants, and written consent was obtained from parents or caregivers. The procedures complied with the principles of the Helsinki Declaration, and approval was granted by the Standing Committee for Scientific Research Ethics at Jazan University (Ref: REC-43/06/120).

Fabrication of audio and video files

An Arabic oral hygiene booklet served as the source for routine oral hygiene guidance in Group I for both blind and deaf subjects [29]. At the deaf school, sign language specialists conveyed the booklet content, and four dental interns received training from these specialists to ensure accurate delivery. A total of 10 instructional videos (MP4 format) were created using the same material as the booklet. International recommendations were applied to maintain dark backgrounds for optimal sign visibility, and all videos featured Arabic subtitles. Additionally, 10 audio recordings (MP3 format) containing the oral hygiene instructions were produced for participants with visual impairment.

Development of the mobile application

At the same time, a developer from Studyleague IT Solutions (India) created the initial build of the Telesmile app for both Android and iOS devices. The app was produced using the Corona framework (Corona Labs, CA, USA) and then reviewed by the research team for interface clarity, visual balance, ease of navigation, operational stability, and layout examples. After generating the ARL (Application Recognition Library) file, the APK (Android Package Kit) was submitted to the Google Play Store together with all relevant coding elements and resources. Specialists examined both the content and the interface, and once approved, the corresponding IPA (iOS Package App Store) version was prepared and uploaded to the Apple App Store. The Push Notification setup was repeatedly tested and corrected using the APS (Apple Push Notification Service) key to meet Apple's configuration requirements and obtain final acceptance.

Once the Telesmile mobile application passed the review process, beta testing was undertaken to check real-time performance and identify any remaining errors before public release **(Figure 2)**. During this stage, the research team was trained to use the administrative panel responsible for managing and uploading multimedia files. After the app became available on both platforms, the set of 10 MP3 audio files for blind users and 10 MP4 video files for deaf users was uploaded and made accessible to the intended audience **(Figures 3–8).**

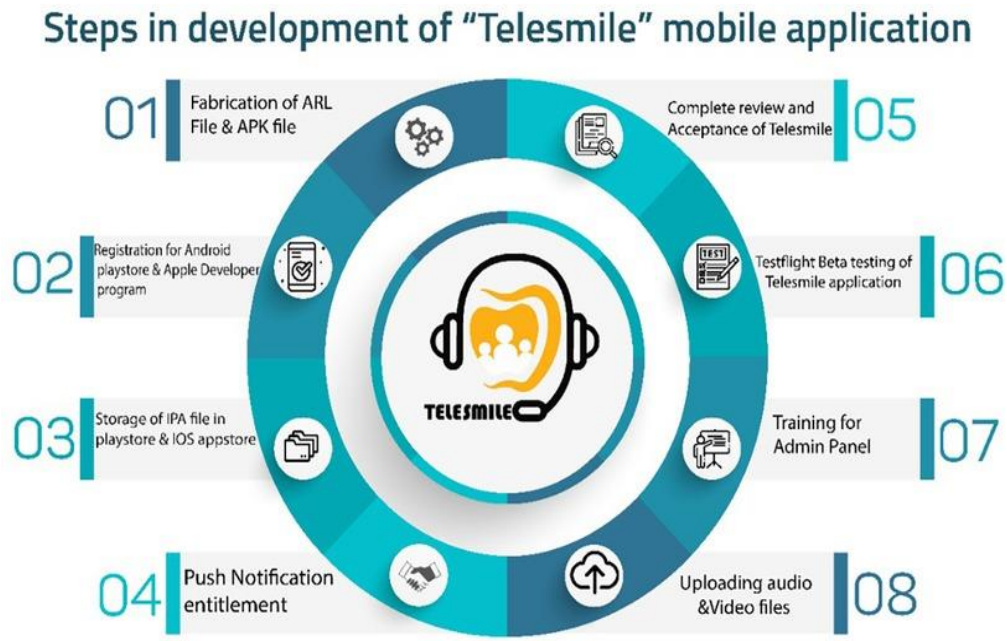


Figure 2. Procedures involved in creating the Telesmile app for Android and iOS.

Figure 3. Opening interface for blind and deaf users.

Figure 4. Page displaying the oral hygiene instructions for the blind category.

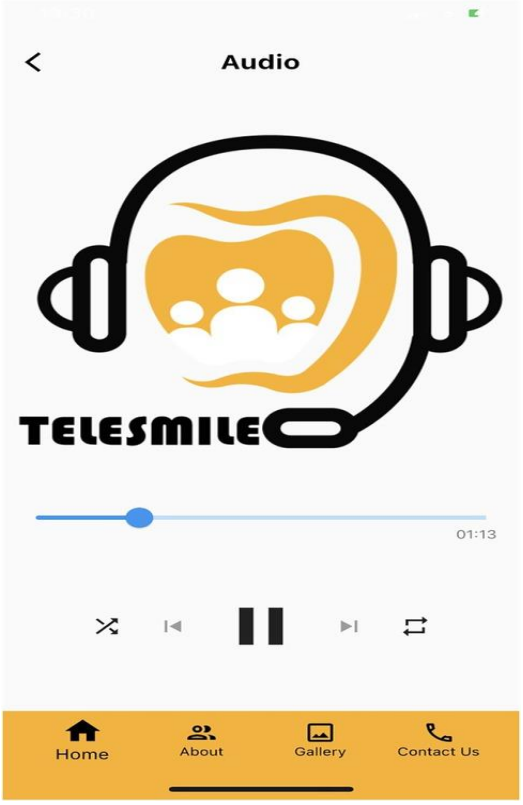


Figure 5. Page containing audio clips for blind users.

Figure 6. Menu showing oral hygiene lessons for deaf participants.

Figure 7. Video options available for deaf users.

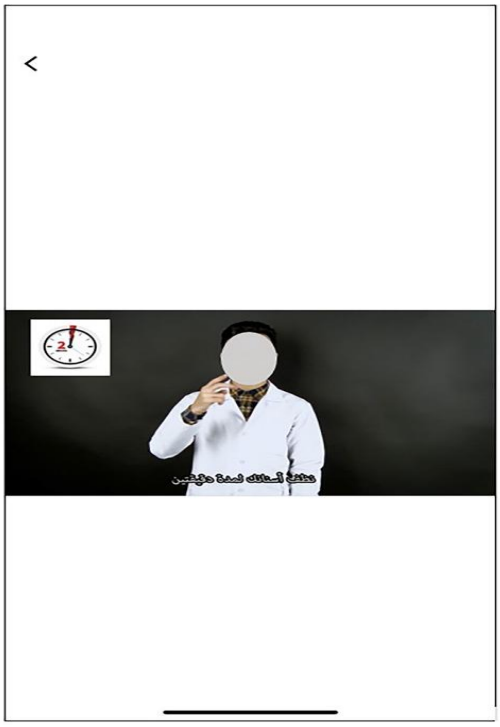


Figure 8. Example of an Arabic sign-language instruction video for deaf participants.

Questionnaire for assessment of knowledge

A structured 14-item questionnaire was created for both blind and deaf participants and translated into Arabic to examine their understanding, attitudes, and routine practices concerning oral hygiene and oral health. This tool had already been validated in earlier published research [30]. A preliminary test was conducted to confirm reliability, resulting in a Cronbach's alpha of 0.91. Participants completed the questionnaire before and after viewing the multimedia material in the app. Each item offered multiple-choice responses; correct answers were assigned a score of "1," and incorrect responses a "0," allowing calculation of total knowledge scores.

Study protocol

This investigation used a randomized controlled parallel design conducted between February 2022 and May 2022 at the College of Dentistry, Jazan University, Saudi Arabia. A total of 50 blind and 50 deaf students from schools throughout Jazan Province were enrolled. The sample size for each subgroup was based on an earlier study evaluating sign-language oral hygiene instruction among hearing-impaired adults in Saudi Arabia [30]. Participants in both categories were divided into two subgroups—Group I (control) and Group II (intervention)—with 25 individuals in each. All participants first completed the questionnaire at their respective schools to establish baseline knowledge.

The examiner remained blinded throughout the process and did not know participant assignments. Before data collection began, a formal protocol was followed. A trained representative from the blind or deaf school accompanied each participant to ensure complete understanding of the questionnaire. After baseline assessment, Group II participants were provided access to the mobile app, while Group I continued to receive verbal instructions (blind group) or the printed booklet (deaf group).

Group II blind participants were instructed to listen to the audio files daily for 4 weeks, and Group II deaf participants were asked to watch the video files once per day for the same duration. Group I deaf participants were instructed to review the booklet every day for 4 weeks, while Group I blind participants continued receiving daily verbal explanations. Caregivers supervised app usage to ensure that Group II adhered to the daily routine throughout the 4-week period. At the end of the 4 weeks, the same questionnaire was administered again to measure the impact of the Telesmile teledentistry intervention on oral health knowledge and oral hygiene practices among both blind and deaf individuals.

Randomization

A total of 50 blind individuals and 50 deaf individuals were allocated to Groups I and II through a randomization method that used sealed envelopes labeled with the assigned group. Group I participants did not undergo the intervention, whereas Group II participants received the intervention outlined in the study protocol. A biostatistician created the envelopes using computer-generated random sequences to ensure concealment of both the sequence and the assignment. An independent assistant with no involvement in the research and unaware of the envelope contents distributed them. Both participant categories were divided into two equally sized subgroups in a 1:1 ratio (n = 25).

Statistical analysis

Data analysis was performed using the Statistical Package for the Social Sciences (SPSS) version 20.0 for Windows (SPSS Inc., Chicago, IL, USA). Chi-square tests were employed to examine knowledge related to oral health and hygiene after use of the Telesmile mobile application among blind and hearing-impaired participants. A 5% significance level was applied.

Results and Discussion

Overall, 50 blind and 50 deaf participants were included, with mean ages of 15.7 years for the blind group and 15.6 years for the deaf group. **Figures 1a and 1b** present the flow diagram of participant progression and interventions. The aim of this investigation was to assess how effectively the Telesmile mobile application enhanced oral health and hygiene awareness among blind and deaf users. The study concluded without any adverse effects. The questionnaire consisted of 14 closed-ended items, scored as "1" for correct and "0" for incorrect responses **(Table 1).**

Table 1. Questionnaire used to evaluate oral hygiene knowledge among blind and deaf participants.

S. No.	Questions	Multiple Choice Options	Response
1	How many times per day should teeth be brushed?	a. Never brush your teeth b. Brush once daily c. Brush twice daily d. Brush once or twice weekly	

2	Which toothbrush bristle type is most suitable to use?	a. Any bristle type (I do not usually pay attention) b. Soft-bristled toothbrush c. Medium–hard bristles d. Hard bristles
3	Which toothpaste helps prevent cavities?	a. Fluoride toothpaste b. Toothpaste for sensitivity c. Anti-plaque toothpaste d. Any available toothpaste
4	At what angle should the toothbrush be placed against the teeth while brushing?	a. Hold bristles parallel to the tooth surface b. Hold bristles perpendicular to the tooth surface c. Position bristles at a 45° angle to the tooth surface d. Move the brush in all directions
5	How frequently should a toothbrush be replaced?	a. Every 3 months b. Every 6 months c. Every 1 year d. Not sure
6	How often should an interdental brush be used?	a. Once each day b. Twice each day c. Once each week d. I am unfamiliar with this type of brush
7	How often should dental floss be used?	a. Once daily b. Twice daily c. Once weekly d. Once monthly
8	Which type of mouthwash is recommended for lowering bacteria and managing gingivitis?	a. Cosmetic mouthwash b. Fluoride-based mouthwash c. Therapeutic mouthwash d. Any kind of mouthwash
9	How often should you see a dentist for routine check-ups and cleaning?	a. Every 3 months b. Every 6 months c. Once a year d. Only visit when a problem appears
10	What type of diet best supports healthy teeth and gums?	a. Sweet foods with all meals (cakes, pastries, ice cream) b. Soft drinks like Coca-Cola or Pepsi with meals c. Fruit juice after each meal d. Fiber-rich foods such as apples, carrots, and salads with meals
11	Why might teeth feel sensitive after a standard scaling procedure?	a. A portion of the tooth is removed during scaling b. Gum tissue is removed from the tooth during scaling c. The tooth weakens and fractures on its own after scaling d. Deposits are cleared from root surfaces, briefly exposing teeth to temperature sensitivity
12	After using mouthwash, how long should you wait before drinking or eating?	a. 5 minutes b. 30 minutes c. 2 hours d. Unsure
13	When rinsing with mouthwash, how long should it be swished around the teeth?	a. Put it in the mouth and spit out immediately b. Swish for 30–60 seconds c. Swish for 5 minutes d. Unsure
14	Which kind of toothbrush is most likely to harm the gums and contribute to gum disease?	a. Soft-bristled toothbrush b. Medium-bristled toothbrush c. Hard-bristled toothbrush d. Electric toothbrush

A chi-square comparison of accuracy across all 14 items before and after the intervention was conducted between blind participants using the Telesmile application and those receiving verbal guidance, as well as between deaf participants using the Telesmile application and those receiving booklet-based instructions. After intervention, participants exposed to the Telesmile application demonstrated significantly higher correct response rates ($p < 0.001$) in both sensory-impaired groups compared with those receiving traditional instruction methods **(Table 2).**

Table 2. Knowledge assessment on oral health and hygiene before and after use of the Telesmile mobile application among blind and deaf subjects.

Survey Items	**Blind Participants – Spoken Guidance**	**Blind Participants – Telesmile App**	**Deaf Participants – Booklet Guidance**	**Deaf Participants – Telesmile App**	**Chi-square**	**p-value**
Pre	**Post**	**Pre**	**Post**	**Pre**	**Post**	**Pre**
Item 1	6 (24%)	7 (28%)	12 (48%)	22 (88%)	4 (16%)	6 (24%)
Item 2	6 (24%)	6 (24%)	6 (24%)	19 (76%)	6 (24%)	10 (40%)

Item 3	2 (8%)	4 (16%)	6 (24%)	20 (80%)	2 (8%)	4 (16%)
Item 4	1 (4%)	4 (16%)	4 (16%)	17 (68%)	4 (16%)	4 (16%)
Item 5	11 (44%)	9 (36%)	10 (40%)	21 (84%)	10 (40%)	10 (40%)
Item 6	1 (4%)	0 (0%)	3 (12%)	16 (64%)	2 (8%)	6 (24%)
Item 7	1 (4%)	5 (20%)	7 (28%)	18 (72%)	2 (8%)	5 (20%)
Item 8	2 (8%)	9 (36%)	4 (16%)	17 (68%)	7 (28%)	8 (32%)
Item 9	2 (8%)	7 (28%)	4 (16%)	20 (80%)	3 (12%)	4 (16%)
Item 10	16 (64%)	16 (64%)	18 (72%)	23 (92%)	9 (36%)	10 (40%)
Item 11	12 (48%)	5 (20%)	15 (60%)	21 (84%)	10 (40%)	11 (44%)
Item 12	8 (32%)	11 (44%)	3 (12%)	19 (76%)	6 (24%)	5 (20%)
Item 13	9 (36%)	6 (24%)	12 (48%)	18 (72%)	8 (32%)	5 (20%)
Item 14	11 (44%)	12 (48%)	18 (72%)	20 (80%)	6 (24%)	8 (32%)

Additionally, both the 50 hearing-impaired participants and the 50 visually impaired participants initially showed insufficient understanding regarding recommended brushing frequency, suitable toothbrush bristles, ideal toothpaste for caries prevention, and correct brushing approaches. Before receiving any guidance, only 6 (24%) in Group I and 12 (48%) in Group II of the blind participants answered Q1 correctly; these increased to 7 (28%) and 22 (88%) after 4 weeks of verbal instruction and Telesmile application use, respectively. For deaf participants, correct responses to Q1 were 4 (16%) in Group I and 12 (48%) in Group II at baseline, rising to 6 (24%) and 23 (92%) after 4 weeks of booklet instruction and Telesmile usage.

Comparable improvements were also seen for questions on ideal bristle type, toothpaste type, brushing technique, and toothbrush replacement timing (Q2–Q5), particularly among Group II participants **(Table 2)**.

Most blind and deaf individuals initially lacked awareness regarding interdental brushes and dental floss **(Table 2)**, (Q6 and Q7). Only minor gains were noted in deaf participants in Group I after booklet guidance, whereas Group II demonstrated notable increases: 56% and 16% among deaf participants and 64% and 72% among blind participants for interdental brush and floss usage, respectively, following 4 weeks of Telesmile instruction via Arabic sign language videos and verbal explanations.

Knowledge regarding mouthwash use was initially low, with correct responses from only 8% of blind participants and 28% of deaf participants in Group I **(Table 2)**, (Q8**)**. After 4 weeks of Telesmile application use, correct responses rose to 68% among blind participants and 92% among deaf participants in Group II.

As reported in **Table 2**, only 8% of blind individuals in Group I and 16% in Group II demonstrated any awareness of the need for routine dental visits (Q9). Among the deaf participants, the corresponding values were 12% in Group I and 8% in Group II. After verbal explanations were provided, correct responses rose only to 28% in Group I, whereas Group II showed a marked improvement, reaching 80% in both the blind and deaf groups. Both sets of participants displayed acceptable understanding regarding diet requirements essential for maintaining periodontal health (Q10).

For items related to tooth sensitivity following professional cleaning (Q11), appropriate use of mouthwash (Q12 and Q13), and the toothbrush type recommended for protecting the gingiva (Q14), Group II—both blind and deaf participants—showed notable gains once they received instruction through the Telesmile mobile platform **(Table 2).**

The initial assumption proposed no measurable difference between the mobile app and the conventional instructional formats (verbal or booklet). The results, however, showed a clear rise in participant knowledge after exposure to the Telesmile application.

The low p-value (≤0.05) provided strong grounds for rejecting the null hypothesis. The Telesmile program incorporated 10 Arabic audio files and 10 subtitled Arabic sign-language videos focused on oral-health topics **(Figures 3 and 5)**. Various earlier studies have pointed out the generally poor oral status and limited hygiene-related knowledge among blind and deaf student groups [31–35]. Because targeted educational tools for these populations remain scarce, and because digital learning programs have demonstrated positive outcomes for similar groups [36], this study chose to develop a specialized mobile resource. Gentry *et al.* also noted the benefits of multimedia-based instruction when evaluating reading comprehension among deaf individuals in Louisiana and Texas [37].

Participants aged 12–18 years from schools serving blind and deaf students were included, provided that they were able to operate the application. One feature built specifically for blind users was an automatic playback function: if the app remained idle for 10 seconds after being opened, all 10 audio segments began playing sequentially without any gestures required **(Figure 4).** This capability was explained to the blind participants and their caregivers. The number of instructional clips was capped at 10 because adding more could reduce ease of use and disrupt communication between dental staff and visually or hearing-impaired patients. Topics included: (1) the significance of oral cleanliness, (2) choosing toothbrushes and toothpastes, (3) proper brushing approaches, (4) interdental cleaning aids, (5) flossing guidance, (6) how mouthwash supports oral health, (7) diet recommendations, and [8–10] information about post-extraction guidance, tooth sensitivity, and children's oral care.

The outcomes showed substantial growth in oral-health knowledge and oral-hygiene awareness among both blind and deaf participants following their use of Telesmile. This can be linked to the simplified structure of the audio and video explanations—brief, slow, and direct content tends to be easier for these groups to process. When visuals were needed, relevant images were added to the top-right area of the video frame using Adobe Premiere Pro CS3. Visual cues and animations help reinforce learning. Because deaf students rely on visual clarity, particular attention was given to precise hand and lip movements **(Figure 7)**, and the clips were intentionally kept short to avoid fatigue.

Although this project demonstrated clear educational benefits, additional research involving larger samples and objective clinical measures—such as plaque levels or bleeding on probing—would be valuable for further evaluation of the Telesmile application.

Conclusion

The Telesmile mobile platform can significantly advance oral-health knowledge and hygiene practices among blind (visually impaired) and deaf (hearing-impaired) populations. Audio-based instruction appears highly suitable for visually impaired children, while video-based demonstrations offer an effective approach for improving oral-health understanding in deaf participants.

Acknowledgments: None

Conflict of Interest: None

Financial Support: None

Ethics Statement: The studies involving humans were approved by the Standing Committee for Scientific Research Ethics at Jazan University (Ref: REC-43/06/120). The studies were conducted in accordance with the local legislation and institutional requirements. Written informed consent for participation in this study was provided by the participants' legal guardians/next of kin.

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