Sign language based educational interventions vs. other educational interventions to improve the oral health of hearing-impaired individuals: A systematic review and meta-analysis

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Objective: Individuals with special needs requiring special care are more vulnerable to oral health problems. Sign language is a communication medium and language of instruction for individuals with hearing impairments. The purpose of this systematic review and meta-analysis was to assess the effectiveness of sign language-based educational interventions compared to other educational interventions in improving the oral health of hearing-impaired individuals. Methods: PubMed, Scopus, Embase, and Cochrane Central Register of Controlled Trials databases were searched without any restriction on the publication date. Analytical and experimental studies that evaluated and compared the effectiveness of sign language with other educational intervention groups such as videos, posters etc were included. Results: Initially, 5568 records were identified. Three relevant publications from India were eligible and included in the systematic review and meta-analysis. Differences were reported in favour of sign language over other interventions concerning plaque status, gingival health, and oral hygiene status. Conclusion: Sign language-based interventions were found to be effective. However, further studies in different locations and populations are required to support their effectiveness.

Keywords: Oral Health, Oral Hygiene, Persons with hearing impairments

Introduction

World Health Organization trends estimate that by 2050, approximately 2.5 billion people (1 in every 4) will experience hearing loss, with nearly 700 million (1 in every 14) living with moderate or higher levels of hearing loss in their better hearing ear (World Health Organization, 2021). The main areas of the world affected by disabling hearing loss are the South Asian, Asia Pacific and Sub-Saharan African regions, with prevalence almost four times greater than high income regions (World Health Organization, 2018). Hearing disorders impact general behaviour and impair social functioning, often leading to the neglect of affected individuals due to ignorance, fear, stigma, misconceptions, and negative attitudes (Pareek et al., 2015).

Individuals requiring special care are particularly vulnerable to oral health problems (Moin et al., 2021). Their potential motor, sensory, and intellectual disabilities limit their ability to maintain proper oral hygiene, making them more susceptible to oral health issues. Previous studies have reported communication challenges with hearing-impaired individuals, resulting in poor patient adherence to treatment. Additionally, this population has a higher prevalence of dental caries and periodontal diseases (Hashmi et al., 2016).

Sign language is used in some countries as a communication medium and language of instruction for individuals with hearing impairments (Jameel et al., 2016). People with hearing impairments have the potential to master sign language, and its extensive use has been beneficial in improving their understanding and communication skills. Additionally, sign language has been used in educational interventions to enhance overall development in students (Staden et al., 2009).

Sign language has also been used in educational interventions to improve the oral health of hearing-impaired individuals. Studies evaluating the effectiveness of sign language-based interventions compared to other interventions have yielded varying findings, with some reporting no differences and others indicating sign language to be more effective (Hashmi et al., 2019; Saikiran et al., 2019; Sudhindra et al., 2020). However, a comprehensive assessment of sign language in educational interventions for the oral health of hearing-impaired individuals has not been conducted. Therefore, this systematic review aimed to compare the effectiveness of educational interventions delivered through sign language with other educational interventions on the oral health of hearing-impaired individuals.

Methods

This systematic review and meta-analysis were conducted following the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) guidelines and registered in PROSPERO (CRD42022363401). The focused question, within the population, intervention, comparison, and outcome (PICO) format, was: Are sign language-based educational interventions compared to other educational interventions effective in improving oral hygiene, plaque, and gingival status among hearing-impaired children and adolescents?
Thus, the included population was hearing-impaired children and adolescents, the intervention was sign language-based educational interventions, the comparison group was other educational interventions and the outcome oral hygiene, plaque or gingival status. Studies conducted or translated into English were included, while editorials, review articles, observational studies, and non-English language studies were excluded.

An electronic search was performed in English-language databases, including PubMed, Scopus, Embase, and the Cochrane Central Register of Controlled Trials, from October 2022 to November 2022. No time frame restriction was applied. Additionally, Google Scholar and Grey literature were searched, and the references of the included studies were examined. The search strategy involved using MeSH keywords (Available at https://www.aiims.edu/index.php?option=com_content&view=article&id=16522&catid=189&lang=en). Two independent reviewers (USB and BP) followed the screened titles and abstracts for inclusion. Duplicates were manually removed. Full articles were then read and analyzed for eligibility, with discrepancies resolved through discussion with the third author (HP). Inter-reliability across the title/abstracts and full-text review stages was measured using Cohen’s Kappa, with reported values of 0.82 and 0.84, respectively.

Data were extracted by one reviewer (USB) and cross-checked independently by the second BP. Data were extracted independently from the included full-text articles. Collated information included author details, participant age range, year of study, sample size, country, intervention, indices, study design, and results. Any inconsistencies were discussed and resolved between the two authors, and missing or unclear information was sought from the authors of the selected papers.

Risk of bias in randomized controlled trials was assessed using the Revised Cochrane risk-of-bias tool for randomized trials. (RoB2), with five domains that evaluate the potential bias introduced (Sterne et al., 2019). For non-randomized controlled trials, the ROBINS2 (“Risk of Bias in Non-randomised studies – of Interventions”) criteria were used (Sterne et al., 2016). RoB 2 is structured into a fixed set of domains of bias, focusing on different aspects of trial design, conduct, and reporting.

Statistical analysis was conducted in Review Manager 5.4. Heterogeneity was assessed using the I² values, and a confidence interval of 95% was used. The data were summarized differences in means. Oral hygiene, gingival, and plaque status were assessed using the random-effects model. ‘Oral hygiene’ and ‘plaque’ were measured with several indices; but all were taken to measure plaque found on and between the teeth.

Results

The initial search yielded 5,568 records. After removing 1365 duplicates, 8 were selected for full-text evaluation for eligibility by the two independent reviewers (Figure 1). The bibliographies of the selected studies were also hand-searched.

Five of the 8 studies were excluded. Two used a single group pre-post-test design (Veriza et al., 2021; Kumiaiawati et al., 2022). One study compared the visual performance reinforcement technique (VPR) with sign language, but the VPR group received sign language-based interventions (Kumar et al., 2022). One study investigated the knowledge and attitudes of caregivers of children with hearing impairments and another compared knowledge change using booklets and sign language videos (Sneha et al., 2022; Fageeh et al., 2020).

Three relevant publications were included in the systematic review and meta-analysis. Oral hygiene status was assessed in two studies, whereas plaque and gingival status were reported in all three.

Table 1 summarises the characteristics and chief findings of the included studies. They were published in 2019 or 2020, and were all conducted in India. Two studies were randomized controlled trials, while one did not explicitly define the design but evaluated two interventions. Only one study reported a gender predilection with male predominance. The participants in all studies were aged 5-20 years, and the sample sizes ranged from 64-178. Validated oral hygiene, plaque, and gingival indices were used to assess the oral hygiene, plaque, and gingival status of the participants.

Figures 2 and 3 report the risk of the bias in the included studies. Two were reported to have high bias, and one had some concerns. The assessment for randomized trials considered bias arising from randomization, deviations from the intended intervention, missing outcome data, measurement of outcome, and selection of the reported result. One study was judged to have an overall high risk of bias due to multiple domains of concern, while the other study was interpreted to have some concerns in two of the five domains. The ROBINS assessment for non-randomized trials revealed serious bias in two domains and low bias in five domains, resulting in an overall judgment of high bias.

The results of the meta-analysis are depicted in Figures 4, 5, and 6. A difference was reported favouring sign language over visual interventions with respect to plaque status ($p = 0.002$, $I^2=84\%$, mean difference $-0.07$, $95\%CI = -0.20,-0.06$), gingival status ($p =<0.001$, $I^2=94\%$, mean difference $-0.05$, $95\%CI = -0.08,-0.01$), and oral hygiene status ($p =<0.001$, $I^2=100\%$, mean difference $-17.68$, $95\%CI = -51.10,-15.75$).

Discussion

Sign language is recognized as a natural language for many deaf and hearing-impaired individuals, with some countries even considering it the first language for deaf people (Jameel et al., 2016). Sign languages are not only linguistically important but also possess complex structures and independent grammar. Therefore, using sign language in interventions to improve the oral health of hearing-impaired individuals is justifiable. However, our findings highlight gaps in the literature regarding the use of sign language in dental health education in this special population. Other interventions, such as posters and videos, primarily rely on the participants’ ability to communicate and learn new activities and behaviours (Balian et al., 2021; Shrivastava et al., 2022).

The studies included in this review compared sign language with other interventions, but variations were observed in the sign language-based interventions. The
Table 1. Characteristics of three included studies.

<table>
<thead>
<tr>
<th>Author</th>
<th>Age (Years)</th>
<th>Year</th>
<th>Sample size</th>
<th>Country</th>
<th>Intervention vs. Comparison</th>
<th>Indices</th>
<th>Study Design</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hashmi</td>
<td>11-20</td>
<td>2019</td>
<td>178</td>
<td>India</td>
<td>Sign language vs Poster (Visual)</td>
<td>OHI-S, Plaque, Gingival</td>
<td>Randomized Double Blind Control Trial</td>
<td>Post-intervention oral hygiene, plaque and gingival index scores were 1.72 &amp; 2.31 (p=0.01), 0.77 &amp; 0.80 (p=0.61), 0.61 &amp; 0.82 (p=0.01) respectively.</td>
</tr>
<tr>
<td>Saikiran</td>
<td>5-15</td>
<td>2019</td>
<td>93</td>
<td>India</td>
<td>Sign language vs Video</td>
<td>Oral Hygiene Status, Plaque Status, Calculus Status</td>
<td>Randomized Controlled Trial</td>
<td>Similar post-intervention debris, calculus, OHI-S, plaque &amp; gingival indices in both groups.</td>
</tr>
<tr>
<td>Baliga</td>
<td>6-13</td>
<td>2020</td>
<td>64</td>
<td>India</td>
<td>Sign language vs Video</td>
<td>Plaque and Gingival Scores</td>
<td></td>
<td>Similar post-intervention plaque and gingival scores in both groups.</td>
</tr>
</tbody>
</table>

Figure 1. Flowchart of records screening through review process.
### Figure 2. Risk of bias - ROB-2 assessment of randomized controlled trials.

<table>
<thead>
<tr>
<th></th>
<th>D1</th>
<th>D2</th>
<th>D3</th>
<th>D4</th>
<th>D5</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hashmi et al. 2019</strong></td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td><strong>X</strong></td>
</tr>
<tr>
<td><strong>Saikiran et al. 2019</strong></td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Judgment:
- **X** High
- - Some Concerns
- + Low

### Figure 3. Risk of bias - ROBINS assessment of non-randomized trials.

<table>
<thead>
<tr>
<th></th>
<th>D1</th>
<th>D2</th>
<th>D3</th>
<th>D4</th>
<th>D5</th>
<th>D6</th>
<th>D7</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Baliga et al. 2020</strong></td>
<td><strong>X</strong></td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td><strong>X</strong></td>
</tr>
</tbody>
</table>

Judgment:
- **X** High
- - Some Concerns
- + Low
- ? No information
frequency of reinforcement and the coupling with other educational materials varied. Reinforcement was daily in one study (Sudhindra et al., 2020), was weekly in another (Saikiran et al., 2019) and monthly (Hashmi et al., 2019) in the remaining study. Additionally, Hashmi et al. (2019) coupled their intervention with a PowerPoint presentation. The interventions were delivered by school caregivers in one study (Sudhindra et al., 2020). Despite these differences, sign language-based interventions were similarly or more effective than visual interventions, such as posters and videos (Hashmi et al., 2019, Sudhindra et al., 2020, Fageeh et al., 2020).

Our meta-analysis supported the effectiveness of sign language in improving oral hygiene, plaque, gingival status, and knowledge levels among hearing-impaired individuals compared to visual interventions. Regarding gender predilection, previous evidence-based literature has shown a higher male prevalence in this special population (Bhadauria et al., 2023). Similar findings were observed in this study, where the only study reporting gender predilection also reported a higher prevalence among males (Hashmi et al., 2019).

It is relevant that most studies on oral health structures in hearing-impaired individuals have been conducted in the South Asia, particularly in India, due to the higher prevalence of hearing impairment in that region (World Health Organization, 2018). The inclusion of studies solely from India might limit the generalizability of the findings globally, underscoring the need for more diverse research on this topic.

The risk of bias tool included for both randomized and non-randomized trials is based on multiple domains. In all the studies, most of the domains were of either of low risk of bias or showed some concerns as judgment. The studies were thus included in the meta-analysis even after questionable overall judgement. Bias due to deviations from the intended intervention, in the selection of the reported results and due to confounding and measurement of outcome were the biases in the included non-randomized studies.

Interventions tailored for special groups of populations may support oral health promotion. Various media, such as Braille, audio tactile performances, and other educational strategies, have shown effectiveness in visually impaired individuals (Bhor et al., 2021). Therapy and skill-based interventions have been utilized for disabled children and adolescents, focusing predominantly on tooth brushing skills (Waldron et al., 2016). Similarly, different visual learning strategies have been found to improve oral hygiene status, oral health-related knowledge and attitudes, and dental anxiety among hearing-impaired individuals (Shrivastava et al., 2022). These interventions and learning strategies equip special populations with essential skills to improve their overall and oral health and require regular updates to align with current skill sets.

While this study strengthens the case for using sign language in educational interventions to improve the gingival, plaque, and oral hygiene status of hearing-impaired individuals, it also highlights the limited number of comparative studies in the past. Additionally, the inclusion of studies only in English and variations in...
interventions limit the generalizability of the findings. Another point to consider is that the number of dentists or dental nurses who are proficient in sign language is likely to be very low in many countries, potentially affecting the implementation of sign language-based interventions.

In conclusion, while sign language-based interventions were found to be effective in improving the oral health of hearing-impaired individuals, the presence of high and concerning bias in the included studies restricts the ability to favor one type of intervention over another. Further studies in diverse geographical locations and populations are necessary to establish the broader effectiveness of sign language-based educational interventions. Efforts should be made to increase the availability of dental professionals proficient in sign language to facilitate the implementation of such interventions effectively.

References


