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Effectiveness of a Scholastic-Supply Model based Oral health intervention among transgender population: A Quasi-Experimental Study

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Research Article

Keywords: Oral Health, Transgender Persons, Oral Hygiene, Health Education, Health Promotion, Vulnerable Populations, Healthcare Disparities

Posted Date: May 25th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-9265563/v1

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Additional Declarations: No competing interests reported.

Abstract

Background:

Transgender population is a marginalized group that has faced social exclusion and structural barriers that affects access to healthcare, including oral health services. There is limited evidence on effective, culturally appropriate oral health interventions for transgender communities in low- and middle-income settings. This study evaluated the effectiveness of customised oral health education intervention in improving oral health knowledge, practices, and clinical status among transgender adults.

Methods:

A quasi-experimental study was conducted among transgender adults in Lucknow, India. Total 400 participants were included in the study, with 200 participants in conventional oral health education group and 200 in intervention group receiving a customised Scholastic Supply (SS) Model based intervention consisting of visual educational aids with oral hygiene supplies. Oral health knowledge, practices, and clinical oral health status were assessed at baseline, three months, and six months using a validated questionnaire and the World Health Organization Oral Health Assessment Form (2013). Intergroup comparisons were performed using chi-square tests, with Cramer's V used to assess the strength of associations.

Results:

At baseline, both groups were comparable across most demographic, knowledge, and oral health practice variables, except for tobacco-related behaviors. By six months, behavioural change was substantially greater in the intervention group, where twice daily brushing increased from 7.5% to 60.1% compared with 10.0% to 18.0% in the conventional group ($p < 0.001$), and a lower prevalence of gingival bleeding at 6 months (27.7% vs 41.9%; OR = 1.88, 95% CI: 1.18–2.97). Improvements in oral health knowledge, oral hygiene practices, and self-reported oral health perceptions were also more pronounced in the intervention group.

Conclusions:

Integration of education with routine oral hygiene aids produced measurable improvements in behaviour and clinical outcomes, indicating that reinforcement-based models can contribute to reducing oral health inequalities among marginalized populations and support inclusive oral health promotion strategies.

1. Background

Health is a dynamic, multidimensional state of wellbeing encompassing physical, mental, and social functioning, and is grounded in principles of dignity and equity. Oral health, as an integral component of general health, is often overlooked and its awareness and access remain limited in among socially marginalised populations.[1, 2]

Health inequalities arise from entrenched social and economic structures that systematically disadvantage socially excluded populations, where denial of basic human rights restrict access to housing, employment, social support, and healthcare, thereby increasing vulnerability to stress, substance use, violence, and preventable morbidity.[3–5]

Although gender diversity has long been recognised within India, historical legal frameworks like section 377 of the Indian Penal Code contributed to sustained marginalisation of gender and sexual minorities. While recent judicial reforms and constitutional recognition have attempted to address these inequalities, their impact on lived experiences and access to healthcare remains limited.[6–9] Transgender individuals are the people whose gender identity does not align with their sex assigned at birth, have continued to experience disproportionate social exclusion and adverse health outcomes.[9, 10]

In recent years, India has introduced several legal and policy measures aimed at reducing these disparities. Recognition of transgender persons as a distinct gender category in 2011, followed by the 2014 Supreme Court judgment affirming third gender status, marked a significant shift at the constitutional level. These developments were operationalised through the Transgender Persons (Protection of Rights) Act, 2019, which established a legal framework to prohibit discrimination and mandate state responsibility for welfare and social inclusion. [11–13]

Access to healthcare services, including oral health, remains constrained by stigma and discriminatory practices within clinical settings, alongside persistently low levels of oral health awareness. Existing research on transgender population in India has been largely centred on HIV and sexually transmitted infections, with comparatively limited attention to broader health domains such as oral health, chronic disease prevention, and health related behaviours. [14, 15]

These gaps are further widened by overlapping structural and systemic factors, including socioeconomic disadvantage, limited provider preparedness for gender affirming care, perceived or experienced discrimination, and clinical environments that are not inclusive.[10, 16]

Oral disease affects an estimated 3.5 billion people globally, with untreated dental caries representing the most common condition. Compromised oral health interferes with basic functions such as eating, speaking, social interaction, often resulting in pain, dietary restriction, and psychosocial impact that collectively reduce quality of life.[17]

Access to dental care remains uneven, with coverage reported at approximately 82% in high-income countries, declining to 75% in upper middle income countries, 60% in lower middle income, and 35% in

low income regions.[17] Oral disease are linked to broader non communicable diseases through shared modifiable risk factors such as tobacco, alcohol, dietary patterns and adverse social conditions.[18]

These disparities are further intensified among transgender populations, where oral health needs remain largely unmet. Studies have reported high prevalence of untreated dental caries, periodontal disease, tooth loss, and oral mucosal lesions, with tobacco related oral lesions affecting 28.5% of transgender individuals. Oral candidiasis is frequently reported within this population and, in some cases, may serve as clinical indicator of underlying systemic conditions, including HIV infection.[19–21]

The persistence of preventable oral conditions reflects systemic gaps in healthcare preparedness, including limited awareness and cultural competence among oral health professionals in addressing the needs of gender-diverse populations.[22]

In view of persistent social marginalization, high levels of unmet oral health needs, limited access to culturally competent dental care, and the scarcity of evidence on community based oral health interventions for transgender populations, the present study aimed to evaluate the effectiveness of a customized Scholastic Supply (SS) Model based intervention on oral health knowledge, practices, and clinical outcomes among transgender adults in Lucknow.

2. Methods

2.1 Study Design & Ethical Approval: A community based, double-blinded quasi-experimental pretest-posttest control group design was employed to evaluate the effectiveness of a customised novel oral health education intervention. Random allocation was not feasible due to ethical and operational constraints inherent in community-based research involving a socially marginalised population; therefore, a quasi-experimental framework was adopted to allow evaluation under real-world conditions while retaining a comparison group to strengthen causal inference.

Ethical clearance was obtained from institutional ethics committee of King George's Medical University, Lucknow (Approval number: 2944/Ethics/2025). Written informed consent was obtained from all participants prior to study commencement. All procedures were conducted with safeguards to ensure confidentiality and anonymity through the study, and in accordance with the Declaration of Helsinki and its subsequent amendments.

2.2 Study Setting and Participants:

The study population comprised of self-identified transgender individuals residing in Gharanas/Deras within Lucknow, Uttar Pradesh, India. Participant recruitment was facilitated through collaboration with non-governmental organisations engaged with transgender communities. Data collection and oral health education activities were carried out in community accessible settings, including outreach sites and designated meeting spaces.

Eligible participants included individuals who self-identified as transgender, were capable of providing responses during assessment, and had given written informed consent. Exclusion criteria comprised of individuals with serious systemic conditions that could interfere with participation, as well as those currently involved in any similar intervention programmes, to limit the potential source of bias.

2.3 Sample Size:

The sample size was determined based on comparison of proportions, using a confidence level of 95% and statistical power of 80%. Drawing on findings from earlier studies, a 15% improvement in oral health knowledge was considered for estimation, which indicated a minimum of 173 participants in each group. This number was subsequently adjusted after applying finite population correction and allowing for a possible 20% loss during follow-up, resulting in a final sample size of 200 participants per group, with a total of 400 individuals included in the study.

2.4 Sampling technique and participant allocation:

Participants were recruited using a non-probability sampling approach. Initial access to the community was achieved using snowball sampling through NGO-supported outreach, followed by an enumerative approach within defined outreach areas, wherein all eligible and consenting individuals encountered during the recruitment period were invited to participate.

Participants were allocated into a control group (Group A) and intervention group (Group B) through contextual and organisational processes inherent to the outreach framework rather than investigator directed randomisation. To minimise contamination, individuals recruited from the same outreach locations or closely connected social networks were assigned to the same study group. Participants from distinct outreach sites and Deras were assigned to separate study groups to minimise contamination and reduce the likelihood of interaction between groups. Baseline demographic, behavioural, and oral health assessments were completed prior to intervention delivery, and group allocation remained fixed throughout the study period.

Owing to the behavioural nature of the intervention, blinding of intervention providers was not possible. However, participants were blinded to group allocation. Investigators conducting clinical oral examinations and administering outcome assessments, as well as data entry personnel and statisticians, were blinded to intervention status through coded datasets. Investigators involved in intervention delivery did not participate in outcome assessment or data analysis. Baseline differences in selected socio-demographic variables were considered during interpretation of findings due to the non-random allocation of participants.

2.5 Study instruments and examiner calibration:

Oral health knowledge, attitudes, practices, and healthcare-seeking behaviour were assessed using a self-developed, structured, close-ended questionnaire designed specifically for the study objectives. Data was collected through interviewer administered face to face interviews conducted by trained investigators, allowing better comprehension and reducing response error given the varying literacy

levels within the population. The questionnaire was pilot tested among 15 individuals who were not included in the final sample, and subsequent modifications were made to improve clarity and contextual suitability. Face and content validity were established by subject experts, with an Item Content Validity Index of 0.82, and internal consistency demonstrated a Cronbach's alpha of 0.86.

Clinical oral health status was assessed using the World Health Organization Oral Health Assessment Form for Adults (2013), including evaluation of dentition status, periodontal status using the modified Community Periodontal Index, oral mucosal lesions, and prosthetic status. Clinical examinations were conducted by four calibrated examiners trained in WHO diagnostic criteria. Examiner calibration was ensured prior to data collection, and intra-examiner reliability assessed through duplicate examinations of 15 participants yielding a kappa value of 0.85. Examinations were performed using standardised mouth mirrors and WHO CPI probes under adequate illumination, following uniform examination protocols with participants in a seated position.

2.6 Intervention:

The intervention was based on the Scholastic–Supply (SS) Model and comprised two complementary components. The first was customised toothpaste cover–based educational aid that integrated image based oral health messages into routine oral hygiene practices. The second was pictorial health education pamphlet developed in the local language, employing visual sequencing and illustrations to convey information on early signs of oral disease, tobacco hazards, oral hygiene practices, oral self-examination, and the importance of regular dental visits. Both components were designed to be culturally appropriate, visually engaging, and suitable for individuals with low literacy, and functioned as in-session educational tools as well as take-home reinforcement materials.

2.7 Study Procedure and follow-up:

At baseline, all participants in both groups underwent assessment prior to any educational exposure. Oral health knowledge, attitudes, practices, and healthcare-seeking behaviour were collected through interviewer-administered questionnaires, followed by a clinical oral examination conducted according to World Health Organization diagnostic criteria to assess dentition status, periodontal condition, and presence of oral mucosal lesions.

Following baseline assessment, the control group received conventional oral health education through standardised session addressing basic oral hygiene practices, common oral diseases, and the importance of oral health maintenance, along with routine informational pamphlets and standard toothpaste and toothbrushes. The intervention group received the customised Scholastic–Supply (SS) Model–based programme, comprising picture-based and model-assisted educational sessions tailored to literacy and contextual needs, along with customised oral hygiene supplies, including illustrated toothpaste packaging and tailored educational pamphlets. All intervention activities were delivered by trained dental public health professionals in familiar community-based settings, with standardisation of content ensured across sessions.

Follow-up assessments were conducted three months and six months post-intervention. At each follow-up, oral health knowledge and clinical oral health status were reassessed using the same instruments and diagnostic criteria applied at baseline to ensure comparability across time points. Participants requiring dental treatment or further evaluation were referred to the nearest accessible oral healthcare facility, independent of study group allocation. Participant loss at each follow up stage was recorded, ad the final analysis was based on per protocol approach. The progression of participants from enrolment through allocation, follow up, and analysis, along with attrition at each stage, is detailed in Fig. 1.

2.8 Statistical analysis:

Data coding, entry, analysis was performed using IBM SPSS Statistics (version 24.0) and Microsoft Excel. Variables were examined for completeness and coding accuracy prior to analysis. Descriptive statistics were used to summarise participant characteristics, oral health knowledge, and oral hygiene practices, with categorical data expressed as frequencies and percentages.

Intergroup comparisons at baseline, three months, and six months were performed using the chi-square (χ^2) test, as most variables were categorical in nature. For contingency tables containing zero cell frequencies or highly sparse distributions, Fisher's exact test was applied. Statistical significance was set at $p < 0.05$. The strength of association between study variables and intervention status, was assessed using Cramer's V and interpreted as negligible (< 0.10), weak (0.10–0.19), moderate (0.20–0.29), or strong (≥ 0.30). Intragroup comparisons were performed using the Wilcoxon signed-rank test, selected due to the ordinal nature of variables and non-normal distribution of data.

3. Result

A total of 400 transgender individuals were included, with equal allocation to the conventional and interventional groups (n = 200 each). Age distribution was comparable between groups, with most participants aged 20–40 years, and no statistically significant difference observed ($\chi^2 = 2.66$, $p = 0.447$). All participants identified as transgender. **(**Table 1**)** At 3 months, follow-up data were available for 180 participants in the conventional group and 186 in the interventional group; at 6 months, 160 and 173 participants, respectively, completed follow-up assessments. **(**Fig. 1**)**

Table 1
Demographic Characteristics of Study Participants

Characteristic	Category	Conventional (n = 200) n (%)	Interventional (n = 200) n (%)	χ^2	p-value	Cramer's V
Age (years)	20–30	93 (46.5)	101 (50.5)	2.66	0.447	0.109
	30–40	90 (45.0)	81 (40.5)			
	40–50	12 (6.0)	16 (8.0)			
	50–60	0 (0.0)	0 (0.0)			
	> 60	5 (2.5)	2 (1.0)			
Gender	Transgender	200 (100.0)	200 (100.0)	NA	NA	NA
Residence	Rural	60 (30.0)	38 (19.0)	6.54	0.011	0.170
	Semi-urban	140 (70.0)	162 (81.0)			
Education status	No formal schooling	120 (60.0)	90 (45.0)	9.15	0.010	0.201
	Primary school (≤ Class 5)	60 (30.0)	85 (42.5)			
	Middle school (Class 6–8)	20 (10.0)	25 (12.5)			
Occupation	Unemployed	20 (10.0)	24 (12.0)	40.10	< 0.001	0.421
	Sex worker	20 (10.0)	42 (21.0)			
	Community events	40 (20.0)	50 (25.0)			
	Begging	40 (20.0)	58 (29.0)			
	Elementary occupation	80 (40.0)	26 (13.0)			
Monthly income (INR)	≤ 7,988	120 (60.0)	108 (54.0)	1.97	0.373	0.093
	7,989–23,869	40 (20.0)	51 (25.5)			
	23,870–39,829	40 (20.0)	41 (20.5)			

Note: *χ^2 test was used for intergroup comparisons of categorical variables. χ^2, p-value, and Cramer's V represent the overall comparison within each characteristic. p-values < 0.05 were considered statistically significant. NA = not applicable*.

Significant intergroup differences were observed in area of residence, education status, and occupation. A higher proportion of participants in the interventional group resided in semi-urban areas compared with the conventional group ($\chi^2 = 6.54$, $p = 0.011$). Educational attainment differed significantly, with no formal schooling more common in the conventional group and primary- and middle-school education more frequent in the interventional group ($\chi^2 = 9.15$, $p = 0.010$). Occupational distribution also varied markedly between groups ($\chi^2 = 40.10$, $p < 0.001$). Monthly income distribution did not differ significantly between groups ($\chi^2 = 1.97$, $p = 0.373$), with the majority of participants in both groups reporting incomes ≤ INR 7,988. Overall, while age, gender, and income were comparable between groups, significant differences were observed with respect to area of residence, education status, and occupation. **(**Table 1**)**

Baseline findings from the WHO Oral Health Assessment (2013) demonstrated that the Conventional and Interventional groups were clinically comparable across all assessed oral health parameters **(**Table 2**)**. No statistically significant intergroup differences were observed for gingival bleeding, periodontal pocket status, loss of attachment, enamel fluorosis, dental erosion, dental trauma, oral mucosal lesions, or intervention urgency categories ($p > 0.05$ for all comparisons).

Table 2
WHO Oral Health Assessment (2013)

WHO variable	Category / Component	Group A (n = 200)	Group B (n = 200)	Statistical test χ^2 (Cramer's V)	p value	OR (95% CI)
DMF	Decayed(D)	1.98 ± 1.30	1.53 ± 1.30	—		
	Missing(M)	0.40 ± 1.89	0.26 ± 0.77			
	Filled(F)	0.31 ± 0.63	0.33 ± 0.65			
	Mean	2.69 ± 2.25	2.12 ± 1.72			
Gingival bleeding	Absent	106 (53.0%)	102 (51.0%)	0.16 (0.020)	0.689	0.92 (0.62–1.37)
	Present	94 (47.0%)	98 (49.0%)			
Periodontal pocket	Absent	106 (53.0%)	109 (54.5%)	0.09 (0.020)	0.764	1.06 (0.72–1.57)
	Present	94 (47.0%)	91 (45.5%)			
Loss of attachment	Absent	106 (53.0%)	120 (60.0%)	1.99 (0.093)	0.158	1.33 (0.90–1.98)
	Present	94 (47.0%)	80 (40.0%)			
Enamel fluorosis	Absent	188 (94.0%)	191 (95.5%)	0.45 (0.034)	0.501	1.35 (0.56–3.29)
	Present	12 (6.0%)	9 (4.5%)			
Dental erosion	Absent	192 (96.0%)	194 (97.0%)	Fisher's exact	0.75	—
	Enamel / dentinal / pulp	8 (4.0%)	6 (3.0%)			
Dental trauma	Absent	200 (100%)	194 (97.0%)	Fisher's exact	0.13	—
	Present	0 (0.0%)	6 (3.0%)			
Oral mucosal lesion	Absent	174 (87.0%)	174 (87.0%)	0.00 (0.00)	1.000	—

WHO variable	Category / Component	Group A (n = 200)	Group B (n = 200)	Statistical test χ^2 (Cramer's V)	p value	OR (95% CI)
	Present	26 (13.0%)	26 (13.0%)			
Intervention urgency	Preventive / routine	38 (19.0%)	36 (18.0%)	0.08 (0.018)	0.962	—
	Prompt treatment	136 (68.0%)	137 (68.5%)			
	Referral needed	26 (13.0%)	27 (13.5%)			

Note: *Categorical variables are presented as n (%) and were compared using the chi-square test. Effect size was assessed using Cramer's V. Odds ratios (OR) with 95% confidence intervals are reported where applicable. Continuous variables (DMFT components) are presented as mean ± standard deviation. A p-value < 0.05 was considered statistically significant; no inferential statistical testing was applied to DMFT variables at baseline.*

Gingival bleeding was present in 47.0% of participants in the Conventional group and 49.0% in the Interventional group. Periodontal pockets and loss of attachment showed similar distributions between groups. The prevalence of other WHO-assessed conditions, including enamel fluorosis, dental erosion, dental trauma, and oral mucosal lesions, was low and comparable across both groups. The majority of participants in both groups required prompt treatment, including scaling, while no participant required immediate urgent care.

As part of the WHO dentition status assessment, dental caries experience was summarized using decayed, missing, and filled teeth components. At baseline, the mean number of decayed teeth was higher in the Conventional group (1.98 ± 1.30) compared with the Interventional group (1.53 ± 1.30). Mean missing teeth were 0.40 ± 1.89 and 0.26 ± 0.77, respectively, while filled teeth were comparable between groups. Consequently, the mean total dentition score derived from the WHO assessment was higher in the Conventional group (2.69 ± 2.25) than in the Interventional group (2.12 ± 1.72). No inferential statistical testing was applied to these baseline dentition measures, as the analysis was descriptive and intended only to characterize baseline oral health status.

Overall, the WHO Oral Health Assessment (2013) confirmed that both groups were clinically comparable at baseline, providing an appropriate foundation for evaluating changes following the intervention. **(**Table 2**)**

At baseline, routine oral hygiene practices were broadly comparable between the conventional and interventional groups (Supplementary Table S1). Daily tooth cleaning was reported by 80.0% and 75.0% of participants, respectively, and once-daily brushing was the most common practice in both groups (70.0% vs 71.0%), with no statistically significant differences. Use of a toothbrush, toothpaste as the

primary cleaning agent, frequency of toothbrush replacement, mouth rinsing after meals, alcohol consumption, and willingness to quit addictive habits were also similar (all $p > 0.05$). In contrast, significant baseline differences were observed for tobacco-related behaviors, with marked intergroup differences in smokeless and smoked tobacco use (both $p < 0.001$). A slightly higher proportion of participants in the interventional group reporting no prior dental visit (92.0% vs 90.0%; $p = 0.484$), although this difference was not statistically significant. **(Supplementary Table S1)**

At the 3-month follow-up, daily tooth cleaning remained comparable between groups (82.8% vs 81.3%; $p = 0.696$). However, brushing frequency differed significantly, with twice-daily brushing more frequent in the interventional group (21.4% vs 14.0%) and once-daily brushing more common in the conventional group (67.7% vs 59.4%; $p = 0.028$) (Supplementary Table S2). Cleaning method, cleaning material, toothbrush replacement, mouth rinsing, and willingness to quit addictive habits did not differ significantly. In contrast, significant intergroup differences persisted for alcohol consumption ($p = 0.011$), smokeless tobacco use ($p < 0.001$), and smoked tobacco use ($p < 0.001$). Dental service utilization was slighly higher in the interventional group, with 14.5% reporting at least one lifetime dental visit compared with 11.1% in the conventional group ($p = 0.204$), although this difference was not statistically significant. **(Supplementary Table S2)**

By 6 months, pronounced and consistent intergroup differences were evident across multiple oral health practice parameters, favouring the interventional group (Supplementary Table S3). Daily tooth cleaning was more prevalent in the interventional group (94.8% vs 86.7%; $p = 0.011$), and twice-daily brushing increased substantially (60.1% vs 18.0%; $p < 0.001$). Use of toothpaste (83.2% vs 69.3%; $p = 0.011$), regular toothbrush replacement every 3–4 months (24.3% vs 8.0%; $p < 0.001$), and mouth rinsing after meals (36.4% vs 16.0%; $p < 0.001$) were significantly higher in the interventional group. Substance-use behaviors continued to differ significantly, including alcohol consumption ($p < 0.001$), smokeless tobacco use ($p < 0.001$), and smoked tobacco use ($p < 0.001$), with higher non-use of smoked tobacco in the interventional group (75.7% vs 50.7%). Motivation to quit addictive habits was greater in the interventional group, with a higher proportion expressing definite intent to quit (31.2% vs 17.3%; $p = 0.013$). Dental service utilization was higher in the interventional group, with 19.0% reporting at least one lifetime dental visit compared with 13.1% in the conventional group ($p = 0.145$), although the difference was not statistically significant. **(Supplementary Table S3)**

Overall, while baseline oral health practices were largely comparable apart from tobacco use and dental visits, progressive and sustained improvements in oral hygiene behaviors, risk reduction, cessation intent, and dental service utilization were observed over time, with consistently superior outcomes in the interventional group.

In the conventional group, significant intragroup improvements were observed from baseline to 3 months for daily tooth cleaning ($p = 0.014$), brushing frequency ($p = 0.004$), toothbrush replacement ($p = 0.001$), mouth rinsing after meals ($p = 0.012$), and smoked tobacco use ($p = 0.047$). These improvements were sustained at 6 months for daily tooth cleaning ($p = 0.002$), brushing frequency ($p < 0.001$),

toothbrush replacement ($p < 0.001$), mouth rinsing ($p = 0.004$), and smoked tobacco use ($p = 0.012$). No significant changes were observed for cleaning method, cleaning aid, alcohol use, smokeless tobacco use, or intention to quit addictive habits at either follow-up. **(**Table 3**)**

Table 3
Intragroup changes in oral health practices from baseline to 3 months and 6 months

OHP item	Baseline to 3 months		Baseline to 6 months	
	Conventional Z (p)	Interventional Z (p)	Conventional Z (p)	Interventional Z (p)
Daily tooth cleaning	−2.449 (0.014)	−3.464 (0.001)	−3.162 (0.002)	−5.916 (< 0.001)
Frequency of tooth cleaning	−2.862 (0.004)	−3.624 (< 0.001)	−3.932 (< 0.001)	−5.757 (< 0.001)
Method of tooth cleaning	−1.732 (0.083)	−2.646 (0.008)	−1.732 (0.083)	−2.828 (0.005)
Cleaning aid used	−0.632 (0.527)	−2.840 (0.005)	−0.535 (0.593)	−2.874 (0.004)
Toothbrush replacement frequency	−3.275 (0.001)	−4.226 (< 0.001)	−4.017 (< 0.001)	−6.475 (< 0.001)
Mouth rinsing after meals	−2.500 (0.012)	−2.887 (0.004)	−2.858 (0.004)	−3.150 (0.002)
Alcohol consumption	−1.000 (0.317)	−2.722 (0.006)	−1.732 (0.083)	−4.227 (< 0.001)
Smokeless tobacco use	−1.667 (0.096)	−2.696 (0.007)	−1.667 (0.096)	−3.974 (< 0.001)
Smoked tobacco use	−1.986 (0.047)	−3.464 (0.001)	−2.500 (0.012)	−5.292 (< 0.001)
Intention to quit addictive habits	−0.913 (0.361)	−1.770 (0.077)	−0.967 (0.333)	−0.747 (0.455)

Note: Intragroup comparisons were performed using the Wilcoxon signed-rank test. Values are expressed as Z-statistics with corresponding p-values in parentheses. Negative Z-values indicate improvement in oral health practices. Statistical significance was set at $p < 0.05$.

In contrast, the interventional group showed statistically significant improvements across most oral hygiene and substance-use behaviors by 3 months, including daily tooth cleaning ($p = 0.001$), brushing frequency ($p < 0.001$), cleaning method ($p = 0.008$), cleaning aid ($p = 0.005$), toothbrush replacement ($p < 0.001$), mouth rinsing ($p = 0.004$), alcohol consumption ($p = 0.006$), smokeless tobacco use ($p = 0.007$), and smoked tobacco use ($p = 0.001$). These improvements were maintained or strengthened at 6 months (all $p < 0.01$), while intention to quit addictive habits remained non-significant. **(**Table 3**)**

At baseline, knowledge across all four domains was uniformly poor and comparable between groups **(Supplementary Table S4)**. Lack of awareness exceeded 85–95% across domains. Perception-related measures, including self-rated oral health, breath status, oral pain, gingival bleeding, and perceived importance of regular dental visits, showed no significant intergroup differences, confirming baseline homogeneity.

At 3 months, early divergence favouring the interventional group emerged **(Supplementary Table S5)**. Awareness that the mouth reflects overall health was higher in the interventional group (27.1%) than the conventional group (17.7%; $p = 0.030$). Perception of harmful substances differed significantly ($p = 0.033$), and symptom-related perceptions improved, with fewer reports of frequent gingival bleeding in the interventional group, however this difference did not reach statistical significance ($p = 0.068$). Other knowledge domains also showed favourable but non-significant trends.

By 6 months, consistent and significant intergroup differences were observed across most knowledge domains **(Supplementary Table S6)**. Awareness of the mouth-overall health link (49.7% vs 25.3%), oral-systemic disease relationship (39.3% vs 22.7%), oral examination for HIV detection (36.4% vs 16.0%), and harmful effects of addictive substances (46.2% vs 32.0%) was significantly higher in the interventional group ($p \leq 0.009$).

Perception-based outcomes also improved markedly at 6 months in the interventional group. More participants rated their oral health as good (24.3% vs 8.0%), reported fresh breath (44.5% vs 37.3%), and indicated absence of oral pain (45.7% vs 26.0%). Gingival bleeding perception shifted favourably, with higher reporting of rare or no bleeding ($p < 0.001$). Preventive orientation strengthened, with more participants in the interventional group rating regular dental visits as extremely important (24.3% vs 8.0%; $p < 0.001$). No significant intergroup difference was observed for the impact of oral pain on eating ability.

Both groups showed improvement over time however, changes were observed earlier and were more pronounced in the intervention group, with effects maintained across the follow up period. Improvements were evident in oral health knowledge, symptom perception, and attitudes. The increasing effect sizes from baseline to six months indicate a sustained impact of the intervention compared with conventional care.

Intragroup analysis using the Wilcoxon signed-rank test (Z-statistics) showed significant improvements in oral health knowledge and selected perception-related outcomes in both groups, with more consistent and sustained changes in the interventional group. **(**Table 4**)**

Table 4

Intragroup changes in oral health knowledge and perception from baseline to 3 months and 6 months

Knowledge & Perception	Baseline to 3 months		Baseline to 6 months	
	Conventional	Interventional	Conventional	Interventional
	Z (p)	Z (p)	Z (p)	Z (p)
Mouth as mirror of overall health	−3.873 (< 0.001)	−5.824 (< 0.001)	−4.796 (< 0.001)	−8.497 (< 0.001)
Oral–systemic disease relationship	−3.606 (< 0.001)	−4.583 (< 0.001)	−4.359 (< 0.001)	−6.782 (< 0.001)
Oral examination detects HIV	−4.000 (< 0.001)	−5.196 (< 0.001)	−4.899 (< 0.001)	−7.937 (< 0.001)
Addictive substances harm oral health	−3.464 (0.001)	−4.583 (< 0.001)	−4.243 (< 0.001)	−6.782 (< 0.001)
Self-perceived oral health status	−2.078 (0.038)	−2.303 (0.021)	−1.547 (0.122)	−2.311 (0.021)
Self-rated breath status	−3.000 (0.003)	−1.271 (0.204)	−3.317 (0.001)	−1.391 (0.164)
Oral pain/discomfort experience	−2.195 (0.028)	−3.800 (< 0.001)	−2.788 (0.005)	−5.675 (< 0.001)
Gingival bleeding perception	−0.279 (0.780)	−3.589 (< 0.001)	−0.290 (0.772)	−5.546 (< 0.001)
Impact of pain on eating	−1.931 (0.053)	−0.688 (0.491)	−2.640 (0.008)	−2.537 (0.011)
Perceived most harmful substance	−2.646 (0.008)	−0.333 (0.739)	−2.940 (0.003)	−0.655 (0.513)
Importance of regular dental visits	−3.598 (< 0.001)	−2.606 (0.009)	−4.333 (< 0.001)	−3.526 (< 0.001)

Note: Intragroup comparisons were performed using the Wilcoxon signed-rank test. Values are presented as Z-statistics with corresponding p-values in parentheses. Negative Z-values indicate improvement in knowledge or perception. Statistical significance was set at $p < 0.05$.

Awareness that the mouth reflects overall health, understanding of the oral–systemic disease relationship, recognition of oral examination in detecting sexually transmitted diseases including HIV, and awareness of the harmful effects of addictive substances on oral health improved significantly in both groups at 3 months and remained significant at 6 months (all $p < 0.001$), with larger Z-values observed in the interventional group.

For perception-related outcomes, self-rated oral health status improved at 3 months in both groups (conventional $p = 0.038$; interventional $p = 0.021$), but this improvement was sustained at 6 months only

in the interventional group (p = 0.021). Perceived breath status improved significantly only in the conventional group at both follow-ups (p = 0.003 and p = 0.001).

Experience of oral pain or discomfort decreased significantly in both groups, with greater reductions in the interventional group at both 3 and 6 months (both p < 0.001). Perceived gingival bleeding improved significantly only in the interventional group at both follow-ups (both p < 0.001). Functional impact of oral pain on eating showed delayed improvement, reaching significance at 6 months in both groups (conventional p = 0.008; interventional p = 0.011).

Perception of the most harmful substance improved significantly only in the conventional group (p = 0.008 and p = 0.003). Attitudes toward regular dental visits improved significantly in both groups at 3 and 6 months (all p ≤ 0.009), with greater change in the interventional group. **(**Table 4**)**

At 3 months, the mean number of teeth with gingival bleeding was significantly lower in the interventional group compared with the conventional group (1.53 ± 1.64 vs. 2.06 ± 1.98; z = − 2.45, p = 0.014). However, when gingival bleeding was analysed as a binary outcome (present/absent), no statistically significant intergroup difference was observed at this time point (38.2% vs. 44.2%; p = 0.241; OR = 1.28, 95% CI: 0.85–1.95). **(**Table 5**)**

Table 5
Intergroup comparison of gingival bleeding status and number of affected teeth at 3 months and 6 months

Time point	Outcome	Conventional	Interventional	Statistical test	p-value	Effect estimate
3 months	Gingival bleeding (no. of teeth), mean ± SD	2.06 ± 1.98	1.53 ± 1.64	Mann–Whitney U (z = − 2.45)	0.014	—
	Gingival bleeding status, n (%)	80 (44.2) present	71 (38.2) present	χ^2 (V = 0.061)	0.241	OR = 1.28 (0.85–1.95)
6 months	Gingival bleeding (no. of teeth), mean ± SD	1.24 ± 1.46	0.95 ± 1.39	Mann–Whitney U (z = − 2.01)	0.044	—
	Gingival bleeding status, n (%)	67 (41.9) present	48 (27.7) present	χ^2 (V = 0.150)	0.007	OR = 1.88 (1.18–2.97)

Note: Gingival bleeding status is presented as n (%) and compared using the chi-square test, with effect size expressed as Cramer's V and odds ratios (OR) with 95% confidence intervals where applicable. Gingival bleeding severity (number of affected teeth) is presented as mean ± standard deviation and compared between groups using the Mann–Whitney U test. A p-value < 0.05 was considered statistically significant.

At 6 months, both the prevalence and severity of gingival bleeding differed significantly between groups. The interventional group exhibited a lower mean number of bleeding teeth than the conventional group (0.95 ± 1.39 vs. 1.24 ± 1.46; z = − 2.01, p = 0.044). In addition, the proportion of participants with gingival bleeding was significantly lower in the interventional group (27.7%) compared with the conventional group (41.9%) (p = 0.007), with a higher likelihood of gingival bleeding observed in the conventional group (OR = 1.88, 95% CI: 1.18–2.97).

Overall, intergroup comparisons demonstrated a progressive reduction in gingival bleeding severity and prevalence over time, with statistically significant differences favouring the interventional group at 6 months. **(**Table 5**)**

Intragroup analysis demonstrated significant reductions in the number of teeth with gingival bleeding in both groups over time. From baseline to 3 months, gingival bleeding decreased by 19.72% in the conventional group (Z = − 4.90, p < 0.001) and by 28.73% in the interventional group (Z = − 5.36, p < 0.001). From baseline to 6 months, larger reductions were observed in both groups, reaching 51.56% in the conventional group (Z = − 6.99, p < 0.001) and 55.66% in the interventional group (Z = − 6.73, p < 0.001). Both groups showed statistically significant improvement, however greater reductions were observed in the intervention group at both follow up assessments **(**Table 6**).**

Table 6
Change in gingival bleeding severity from baseline to 3 months and 6 months

Time interval	**Conventional group**			**Interventional group**		
	% change	**Z-value**	**p-value**	**% change**	**Z-value**	**p-value**
Baseline to 3 months	19.72	−4.90	< 0.001	28.73	−5.36	< 0.001
Baseline to 6 months	51.56	−6.99	< 0.001	55.66	−6.73	< 0.001

Note: Percentage change in gingival bleeding severity (number of affected teeth) was analysed using the Wilcoxon signed-rank test. Values are expressed as percentage change with corresponding Z-values and p-values. A p-value < 0.05 was considered statistically significant.

Discussion

Our study evaluated the effectiveness of a structured oral health education intervention on oral hygiene practices, knowledge, perceptions, and gingival health among transgender individuals over a six-month follow-up period. At baseline, both groups were comparable across key demographic and clinical parameters, with gingival bleeding affecting 47.0% of the conventional group and 49.0% of the

interventional group, alongside markedly low oral health literacy. These findings establish a uniform starting point for assessing intervention related changes.

The demographic profile reflects patterns reported in transgender health research in India, with more than 90% of participants aged 20–40 years. [2, 7, 19] While groups were comparable in age, gender identity, and income, significant differences in education ($p = 0.010$), occupation ($p < 0.001$), and residence ($p = 0.011$) indicate greater social vulnerability in the interventional group. These disparities align with evidence describing lower educational attainment, informal employment, and peri-urban clustering due to structural exclusion.[23–25] The greater improvements observed in the interventional group despite these disadvantages suggest that contextually tailored oral health promotion strategies can attenuate the impact of socio-educational constraints on health behaviour.

Baseline oral hygiene practices were largely similar between groups, with daily tooth cleaning reported by 80.0% of the conventional group and 75.0% of the interventional group, and no meaningful differences in brushing frequency or related practices. However, higher tobacco use and lower prior dental service utilization in the interventional group (88.0% vs 80.0%; $p = 0.029$) indicate a greater baseline behavioural risk, reflecting previously documented patterns of high tobacco exposure and limited access to dental care in this population. [7, 9, 20, 26, 27]

Over time, a clear behavioural trajectory emerged. At 3 months, early improvements were observed in brushing frequency and dental visits, with twice-daily brushing increasing to 21.4% in the interventional group compared with 14.0% in the conventional group ($p = 0.028$), and dental visits reported by 19.0% versus 13.1% ($p = 0.145$), despite directional increase, dental service utilization did not reach statistical significance. At six months, the difference between groups was more evident. Daily tooth cleaning was reported by 94.8% of participants in the intervention group compared with 86.7% in the conventional group ($p = 0.011$), while twice daily brushing increased markedly to 60.1% versus 18.0% ($p < 0.001$). Improvements were also observed in the use of toothpaste (83.2% vs 69.3%), regular replacement of toothbrush (24.3% vs 8.0%), and rinsing after meals (36.4% vs 16.0%), with all differences remaining statistically significant ($p \leq 0.011$). These changes reflect not only a higher frequency of oral hygiene practices but also better adherence to recommended routines. Similar patterns of inadequate baseline practices and subsequent improvements following structured interventions have been reported in earlier studies among transgender population. [2, 7, 28]

The pattern of change over time provides additional insight. These findings indicate that behavioural changes were not uniform across domains, with simpler actions such as brushing frequency improving earlier, while changes in routine maintenance practices appeared gradually with continued exposure.

The observed improvements may be related to the way the intervention was delivered. Educational content was incorporated into materials used during oral hygiene practices, allowing repeated exposure in a routine setting rather than isolated instruction. Similar approaches using repeated prompts within daily routines, including reminder-based strategies and message supported interventions, have

demonstrated improvements in brushing behaviour and preventive practices. [26, 29] In addition, combining educational inputs with provision of oral care materials has been associated with improved behavioural adherence and clinical outcomes, suggesting that both reinforcement and access contribute to sustained change. [30]

Overall differences between groups regarding tobacco related behaviours were significant at six months ($p < 0.001$), a higher proportion of participants in the intervention group reported an intention to quit (31.2% vs 17.3%; $p = 0.013$). this suggests that while awareness and intent may improve, sustained behavioural change in relation to substance use likely requires targeted cessation strategies, given the influence of underlying psychosocial and occupational factors.[20, 31]

Baseline awareness of the relationship between oral and general health was low in both groups, with only 10.0% and 5.0% of participants in the conventional and intervention groups, respectively, recognising this link. Awareness regarding the role of oral examination in detecting HIV or other sexually transmitted conditions was absent at baseline. These findings corroborate previous reports describing low oral health literacy and reliance on symptomatic care.[27, 28, 32]

Following the intervention, progressive improvements were evident. At 3 months, awareness that oral health reflects general health increased to 27.1% in the interventional group compared with 17.7% in the conventional group ($p = 0.030$). By 6 months, this increased to 49.7% versus 25.3%, while understanding of oral–systemic relationships improved to 39.3% versus 22.7% ($p \leq 0.001$). Awareness of oral examination for HIV detection also increased to 36.4% compared with 16.0% ($p < 0.001$). These changes were accompanied by improved perceptions of oral health, and increased recognition of the importance of routine dental visits, demonstrating that repeated and culturally adapted educational inputs can enhance both awareness and risk perception.[21, 33]

These behavioural and cognitive gains were reflected in clinical outcomes. The mean number of teeth with gingival bleeding was significantly lower in the interventional group at 3 months (1.53 ± 1.64 vs 2.06 ± 1.98; $p = 0.014$) and further reduced at 6 months (0.95 ± 1.39 vs 1.24 ± 1.46; $p = 0.044$). Gingival bleeding prevalence declined from 49.0% to 27.7% in the intervention arm compared with 47.0% to 41.9% in the conventional group ($p = 0.007$). These findings are consistent with previous studies. Improved plaque control likely reduces gingival inflammation, supporting the observed periodontal improvements.. [7, 23] This pattern indicates that improvements in oral hygiene behaviour were accompanied by measurable changes in gingival health.

Despite these improvements, persistent gaps in service utilization and tobacco use indicate that improvements in individual behaviour alone are insufficient to fully address broader determinants of oral health.

Existing literature indicates that limitations for this population arise from interconnected structural, educational and provider related gaps. Disparities in health outcomes are closely linked to stigma,

discrimination, and socioeconomic disadvantage, all of which restrict timely access to appropriate healthcare services. In a study, qualitative findings further suggest that these experiences are not isolated but systemic, influencing mental health, care seeking behaviour, and continued engagement with healthcare systems.[34] In addition, broader social determinants, including economic conditions and environmental context, shape patterns of healthcare utilisation among LGBTQ+ populations. [8, 35]

One of the consistent findings across studies is the limited preparedness of healthcare professionals to address the needs of transgender individuals. Exposure of LGBTQ+ health topics within medical and dental training remains insufficient, contributing to gaps in knowledge, uncertainty in patient interactions, and reduced clinical confidence. Only a small proportion of dental students report feeling adequately prepared to manage LGBTQ+ patients, reflecting shortcomings in formal education and institutional support.[22] In addition, limited familiarity with transgender specific terminology and health concerns has been associated with less favourable provider attitudes, although even brief interventions have been shown to improve knowledge and perceptions.[24] Evidence from a systematic review indicates that structured training programmes can enhance knowledge and confidence among healthcare trainees, however most studies are short term and do not assess whether these gains translate into sustained changes in clinical practice.[36] The absence of inclusive environments further contributes to avoidance of healthcare services, thereby deepening oral health inequalities.

Addressing these gaps requires action at multiple levels, including education, clinical practice, and healthcare system as a whole. Within training programmes, there is a need to move beyond minimal inclusion of LGBTQ+ topics toward their systematic integration across the curriculum.[36]

At the level of healthcare providers, continuing professional development is essential to address existing gaps. Training should focus not only on knowledge but also on practical competencies such as respectful communication, understanding gender affirming care, ad recognising relevant risk factors. In previous study familiarity with appropriate terminology and inclusive practices has been shown to improve both provider attitudes and patient experiences.[24]

At system level, ensuring inclusive and accessible healthcare requires non-discriminatory policies, supportive clinical environments, integration of transgender inclusive services within primary and oral healthcare, and strengthened referral pathways. Improving broader structural factors, including socioeconomic disadvantage, remains essential for achieving sustained improvements in health outcomes.[22]

The present study has several strengths. It examines an underrepresented population and provides community-based evidence within the Indian context. The relatively large sample size enhances the reliability of the findings. The quais experimental design with repeated follow up allowed assessment of changes over time. The intervention, by embedding educational cues within daily routines is practically applicable across varying literacy levels. Methodological rigour was supported by the use of standardized WHO assessment methods, examiner calibration, and partial blinding. Additionally, the

inclusion of behavioral, knowledge based, and clinical outcomes enabled a comprehensive assessment of the impact of intervention.

Certain limitations need to be acknowledged. The non-random allocation of participants may have introduced selection bias. Data based on self-reports may be subjected to recall and reporting bias. In addition, loss of follow-up and six-month study period restrict interpretation of long-term sustainability of intervention. Although efforts were made to standardize clinical assessments, some degree of inter examiner variation cannot be entirely ruled out.

From a public health perspective, the findings of our study indicate that community based oral health education can be integrated within existing service platforms for transgender populations rather than delivered as an isolated activity. The intervention used in this study is potentially scalable, as it relies on simple reinforcement through routine oral hygiene practices and community engagement, without the need for complex methods. To address the behavioural and system level factors, previous study has recommended integrated approaches such as Kartavya framework, which combine community education with service provision and provider sensitisation to improve access, acceptability and continuity of care.[37] Further longitudinal research is needed to assess the long term effectiveness of integrated models in improving oral health outcomes among transgender populations.

Conclusion

The present study concluded that a contextually adapted oral health intervention, designed around routine-based reinforcement, can produce meaningful improvements in oral health. The effectiveness of the intervention appears to lie in its integration within everyday routines, enabling repeated exposure and sustained behaviour adoption. It has demonstrated strong potential for scalability. Its adaptability to low literacy contexts and compatibility with routine behaviours make it operationally feasible across similar underserved settings. Integration within broader community based and health system strategies may contribute to reducing oral health inequalities in populations experiencing structural disadvantage.

Abbreviations

SS Model
Scholastic-Supply Model
WHO
World Health Organization
CPI
Community Periodontal Index
DMF
Decayed, Missing, Filled (teeth)
SPSS
Statistical Package for the Social Sciences

χ^2
Chi-square test
OR
Odds Ratio
CI
Confidence Interval
HIV
Human Immunodeficiency Virus
STDs
Sexually Transmitted Diseases
NGO
Non-Governmental Organization
LGBTQ+
Lesbian, Gay, Bisexual, Transgender, Queer and other gender and sexual minorities

Declarations

Ethics approval and consent to participate:

The study was approved by the Institutional Ethics Committee of King George's Medical University, Lucknow (Approval No.: XXX-PGTSC-IIA/P12). Written informed consent was obtained from all participants.

Consent for publication:

Not applicable

Competing interests:

The authors declare that they have no competing interests.

Funding:

It is self-funded research and had received no grant or financial assistance from any funding agency in the public, commercial, or not-for-profit sectors.

Author Contribution

SD, SK conceptualized the study. AA, SG, RN, MA were involved in data collection. GM, VG performed statistical analysis. SK, VG supervised the study. All authors contributed to manuscript preparation and approved the final version.

Acknowledgement

The authors acknowledge the participants for their time and cooperation in this study. We also extend our appreciation to the non-governmental organizations for their support in facilitating community outreach and participant engagement.

Data Availability

The datasets generated and/or analysed during the current study are available from the corresponding author on reasonable request.

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Figures

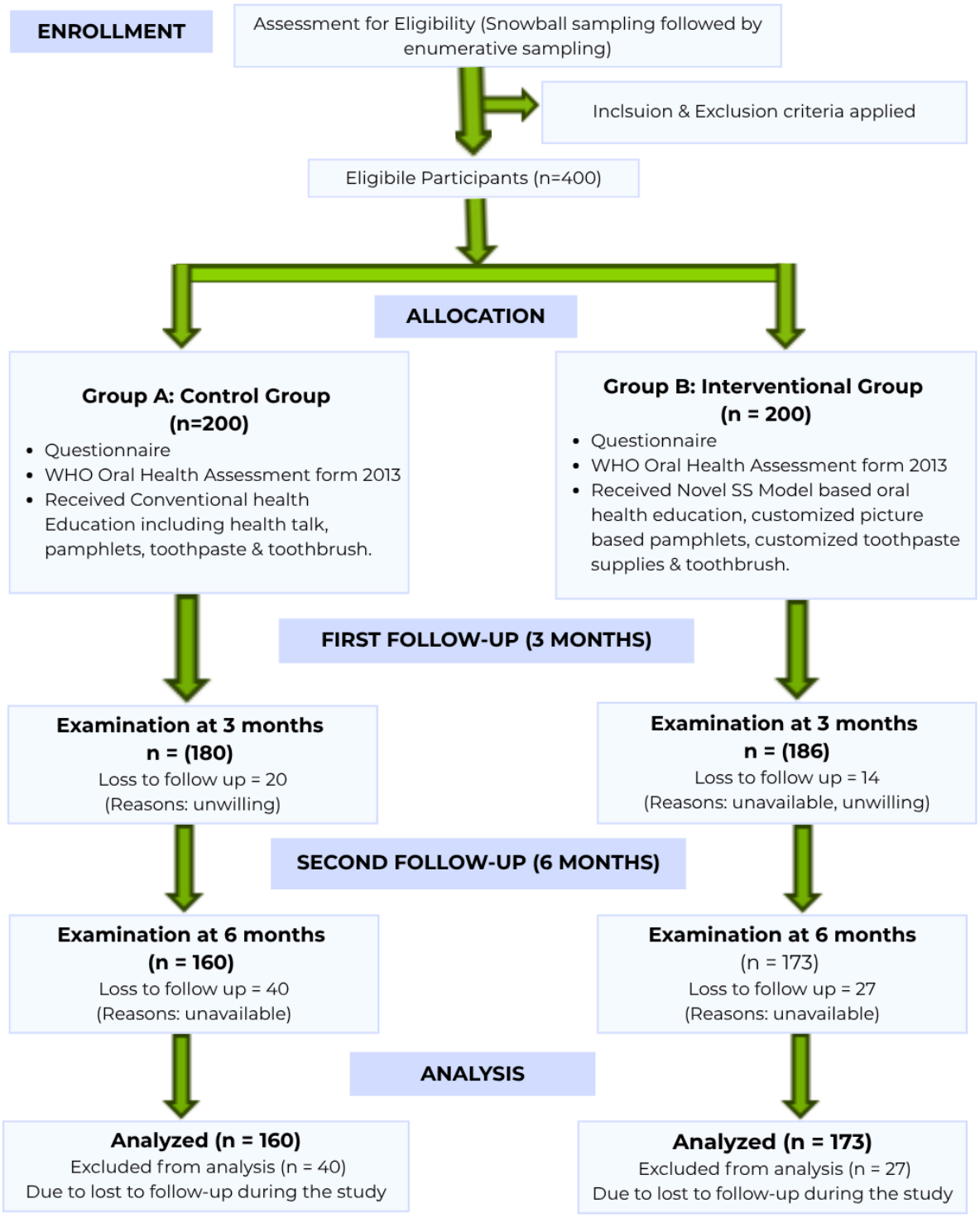


Figure 1

TREND flow diagram showing participant enrolment, allocation, follow-up, and analysis in the quasi-experimental study. The diagram illustrates assessment for eligibility, group allocation, follow-up at 3 and 6

months, losses to follow-up, and the final number of participants included in the analysis for both the conventional and interventional groups.

Supplementary Files

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- supplementarytables.docx