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Genetic Risk Education in Dental Care: Enhancing Knowledge, Enamel Health, and Preventive Behaviors in a Six-Month Cohort Study in South India

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ABSTRACT

Introduction: *Genetic factors and environmental influences, such as frequent bottled water usage, contribute to dental conditions like amelogenesis imperfecta, oral cancer, and enamel erosion, yet patient awareness is low. This study evaluates a brief genetic risk education intervention to enhance knowledge, psychological outcomes, enamel wear, bottled water usage patterns, and preventive intentions.*

Methods: *A six-month prospective cohort study was conducted at Government Dental College and Hospital, RIMS, Kadapa, India, from June 2021 to February 2022, involving 200 adult dental patients. Free, validated scales—Genetic Knowledge Scale, Perceived Risk of Genetic Disorders Scale, Hospital Anxiety and Depression Scale (HADS), Health Action Process Approach (HAPA) intention items, Basic Erosive Wear Examination (BEWE) Index, and a bottled water usage question—assessed outcomes at baseline, 3, and 6 months. A 20-minute educational session on hereditary dental diseases and environmental factors was delivered, with changes analyzed using repeated measures ANOVA.*

Results: *Of 200 patients, 185 completed follow-ups (92.5% retention). Genetic knowledge increased from 50% to 78% ($p<0.001$, Cohen's $d=1.1$). Perceived risk rose from 3.1 to 4.4 ($p<0.001$, Cohen's $d=0.8$). BEWE scores indicated mild erosion in 60% at baseline, reducing to 45% ($p=0.02$). Frequent bottled water usage decreased from 55% to 38% ($p=0.01$). HADS anxiety scores increased transiently (6.4 to 7.0, $p=0.04$) but decreased to 5.9 by 6 months ($p=0.03$). Intentions for genetic counseling (22% to 62%), oral hygiene (48% to 73%), and family history sharing (32% to 66%) increased ($p<0.001$).*

Conclusion: *Brief genetic risk education enhances knowledge, improves enamel erosion and bottled water usage patterns, supports psychological adaptation, and promotes preventive behaviors, offering a scalable model for dental practice.*

Keywords: *Genetic risk education, Enamel erosion, Bottled water usage, Preventive behaviours, Dental care.*

INTRODUCTION

Genetic factors significantly shape dental pathologies, with monogenic disorders like amelogenesis imperfecta (prevalence ~1:14,000) and dentinogenesis imperfecta arising from mutations in genes such as AMELX and DSPP, impairing enamel and dentin integrity [1]. These conditions often follow Mendelian inheritance, necessitating early familial screening to mitigate accelerated erosion risks [2]. Common issues, such as dental caries, stem from polygenic interactions, including IL1A variants, which are exacerbated by environmental factors like fluoride-deficient bottled water, hindering enamel remineralization [3]. Oral cancer, with a global incidence of ~4 per 100,000, is driven by somatic mutations (e.g., TP53) and hereditary syndromes, requiring integrated risk assessment in clinical practice [4].

Despite genomic advances, patient awareness of hereditary and modifiable dental risks remains low, leading to delayed diagnoses and missed preventive opportunities [5]. Individuals with familial dental

histories often fail to pursue actionable steps, such as genetic counseling or adopting fluoridated water sources, particularly in underserved regions like India, where genomic education and water fluoridation are limited [6]. This knowledge gap perpetuates health disparities, underscoring the need for targeted interventions in dental settings to empower patients and align with precision dentistry [7]. Such approaches mirror genomic medicine trends in primary care, where risk communication enhances personalized care and adherence [8].

To evaluate a genetic risk education intervention, validated tools are critical. The Genetic Knowledge Scale measures baseline and post-intervention understanding [9], while the Perceived Risk of Genetic Disorders Scale assesses susceptibility perceptions, a key driver of health behaviors [10]. Psychological impacts, such as anxiety from risk awareness, can be monitored using the Hospital Anxiety and Depression Scale (HADS) [11]. Behavioral intentions, including seeking genetic counseling or modifying water usage, are quantifiable via the Health Action Process Approach (HAPA) [12]. Enamel erosion, a clinical outcome, is assessed using the Basic Erosive Wear Examination (BEWE) Index [13]. Primary care studies show that brief genetic education improves knowledge and engagement, suggesting potential in dental contexts, though this area remains underexplored [14]. Risk disclosure may induce transient anxiety, but careful design promotes adaptive responses [15]. In resource-limited settings, overcoming barriers like provider training and patient literacy requires scalable, accessible models [16].

The need for this study arises from the lack of dental-specific genetic education interventions, particularly in low-resource settings like India, where low genetic literacy and environmental risks exacerbate dental health disparities. The purpose is to develop and evaluate a brief, scalable intervention to enhance patient knowledge, psychological resilience, and preventive behaviors, informing precision dentistry and health equity. The objectives are to: (1) assess changes in genetic knowledge and perceived risk following a 20-minute education session; (2) evaluate impacts on enamel erosion and bottled water usage; (3) measure psychological outcomes (anxiety and depression); and (4) examine intentions for preventive behaviors, including genetic counseling, oral hygiene, and family history sharing. Conducted at Government Dental College and Hospital, RIMS, Kadapa, India, from June 2021 to February 2022, this study aims to establish an evidence-based model for integrating genomic education into dental practice.

METHODOLOGY

Study Design

This prospective cohort study longitudinally evaluated the impact of a genetic risk education intervention on knowledge, psychological outcomes, enamel erosion, bottled water usage, and preventive behavioral intentions among dental patients [8, 9].

Study Setting

The investigation occurred in the outpatient clinics of Government Dental College and Hospital, Rajiv Gandhi Institute of Medical Sciences (RIMS), Kadapa, Andhra Pradesh, India—a tertiary facility serving heterogeneous demographics [7].

Study Population

Eligible participants were adults (18–60 years) seeking routine dental care, with either a self-reported family history of dental/oral disorders or interest in genetic/environmental risk education [1, 5].

Study Period

Enrollment and assessments spanned June 2021 to February 2022, including baseline, intervention, and follow-ups at 3 and 6 months.

Sample Size

The sample size for this study was calculated to detect moderate effect sizes (Cohen's d=0.5) with 80% power and a two-sided significance level of 0.05, accounting for a 10% attrition rate. The calculation was based on the formula for comparing two means:

$$n=2(Z\alpha/2+Z\beta)^2\sigma^2/\delta^2$$

where n is the required sample size per group, $Z\alpha/2=1.96$ corresponds to the 5% significance level, and $Z\beta=0.84$ corresponds to 80% power. σ is the estimated standard deviation of the outcome, and δ represents the minimum detectable effect size. For this study, the sample size was adjusted to accommodate multiple endpoints and potential dropouts, resulting in a target enrollment of 200 participants. This ensures sufficient statistical power to detect clinically meaningful differences across the primary outcomes measured at baseline, and at 3- and 6-month follow-ups.

Sampling Technique

Consecutive sampling recruited eligible patients during June–July 2021 until target attainment, ensuring feasibility and representativeness [6].

Study Instruments

Instruments were validated, freely accessible, and adapted for dental contexts (Cronbach's α ≥0.80):

- **Genetic Knowledge Scale**: 16 true/false items (dental-adapted; 0–100% correct) [10].
- **Perceived Risk of Genetic Disorders Scale**: 7-item Likert (1–5; range 7–35) [11].
- **HADS**: 14 items (anxiety/depression subscales; 0–21 each) [12].
- **HAPA Intention Items**: 3 Likert items (1–5; range 3–15), tailored to dental behaviors [13].
- **BEWE Index**: Clinical erosion scoring (0–18 total) [14].
- **Bottled Water Usage**: Binary query on primary source [4].

Inclusion Criteria

Adults (18–60 years) with family dental history or risk interest, consenting to participation and follow-ups, fluent in English/Telugu.

Exclusion Criteria

Cognitive/psychiatric impairments hindering comprehension; non-English/Telugu speakers.

Ethical Clearance

Institutional Ethics Committee approval was secured; informed consent obtained per Helsinki Declaration, with data anonymized.

Study Procedures

Baseline involved clinical BEWE by trained dentists and self-report surveys [14]. The intervention—a 20-minute multimedia session on genetic risks (e.g., AMELX mutations [2]), environmental factors (e.g., fluoride deficiency in bottled water), and preventive strategies—was delivered post-baseline [9]. Follow-ups replicated assessments via in-person (BEWE) and digital surveys. Standardization ensured through educator training and reminders.

Data Analysis

Data entry used Excel; analysis via SPSS v.20. Repeated measures ANOVA (Bonferroni post-hoc) tested temporal changes; Pearson correlations explored associations. Effect sizes (Cohen's d) quantified magnitude; $p<0.05$ signified significance. Listwise deletion managed minimal missing data (7.5% dropout).

RESULTS

Participant Characteristics

Of 200 patients, 185 completed follow-ups (92.5% retention). Mean age was 35±12 years; 55% were female; 40% reported a family history of dental conditions (e.g., 22% amelogenesis imperfecta, 13% oral cancer susceptibility, 10% enamel erosion). Frequent bottled water usage was reported by 55% at baseline. Table 1 summarizes characteristics.

Table 1. Participant Characteristics (N=185)

Characteristic	Value
Age (mean ± SD)	35 ± 12 years
Female (%)	55%
Family history of dental conditions (%)	40%
- Amelogenesis imperfecta	22%
- Oral cancer susceptibility	13%
- Enamel erosion	10%
- Other (e.g., dentinogenesis imperfecta)	5%
Education (≥ high school, %)	70%
Frequent bottled water usage (%)	55%

Knowledge and Risk Perception

Genetic knowledge scores increased from 50% to 78% correct responses by 6 months ($p<0.001$, Cohen's $d=1.1$). Perceived risk scores rose from 3.1 to 4.4 (5-point scale) by 6 months ($p<0.001$, Cohen's $d=0.8$).

Enamel Erosion

BEWE Index scores indicated mild erosion (score 1–2) in 60% of participants at baseline, reducing to 45% by 6 months ($p=0.02$, Cohen's $d=0.4$). Mean BEWE scores decreased from 3.2 to 2.7 ($p=0.02$).

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Bottled Water Usage

Frequent bottled water usage decreased from 55% to 38% by 6 months (p=0.01, Cohen's d=0.35). Reduced bottled water usage correlated with lower BEWE scores (r=-0.40, p=0.01).

Psychological Impact

HADS anxiety scores increased slightly post-intervention (6.4 to 7.0, p=0.04) but decreased to 5.9 by 6 months (p=0.03). HADS depression scores remained stable (5.1 ± 1.3, p=0.50). No participants exceeded clinical thresholds (HADS ≥8) at 6 months.

Behavioral Intentions

Intentions to seek genetic counseling increased from 22% to 62% (p<0.001), improve oral hygiene from 48% to 73% (p<0.001), and share family history from 32% to 66% (p<0.001). Knowledge gains correlated with intentions (r=0.60, p<0.01) and BEWE score reduction (r=-0.35, p=0.03).

Table 2. Key Outcomes Over Time (N=185)

Outcome	Baseline	3 Months	6 Months	p-value
Knowledge Score (% Correct)	50%	68%	78%	<0.001
Perceived Risk (Mean, 1–5)	3.1	3.9	4.4	<0.001
BEWE Index (Mean, 0–18)	3.2	2.9	2.7	0.02
Frequent Bottled Water Usage (%)	55%	46%	38%	0.01
Anxiety Score (HADS-A, Mean)	6.4	7.0	5.9	0.04
Depression Score (HADS-D, Mean)	5.1	5.2	5.0	0.50
Intention: Genetic Counseling (%)	22%	48%	62%	<0.001
Intention: Oral Hygiene (%)	48%	66%	73%	<0.001
Intention: Family Communication (%)	32%	54%	66%	<0.001

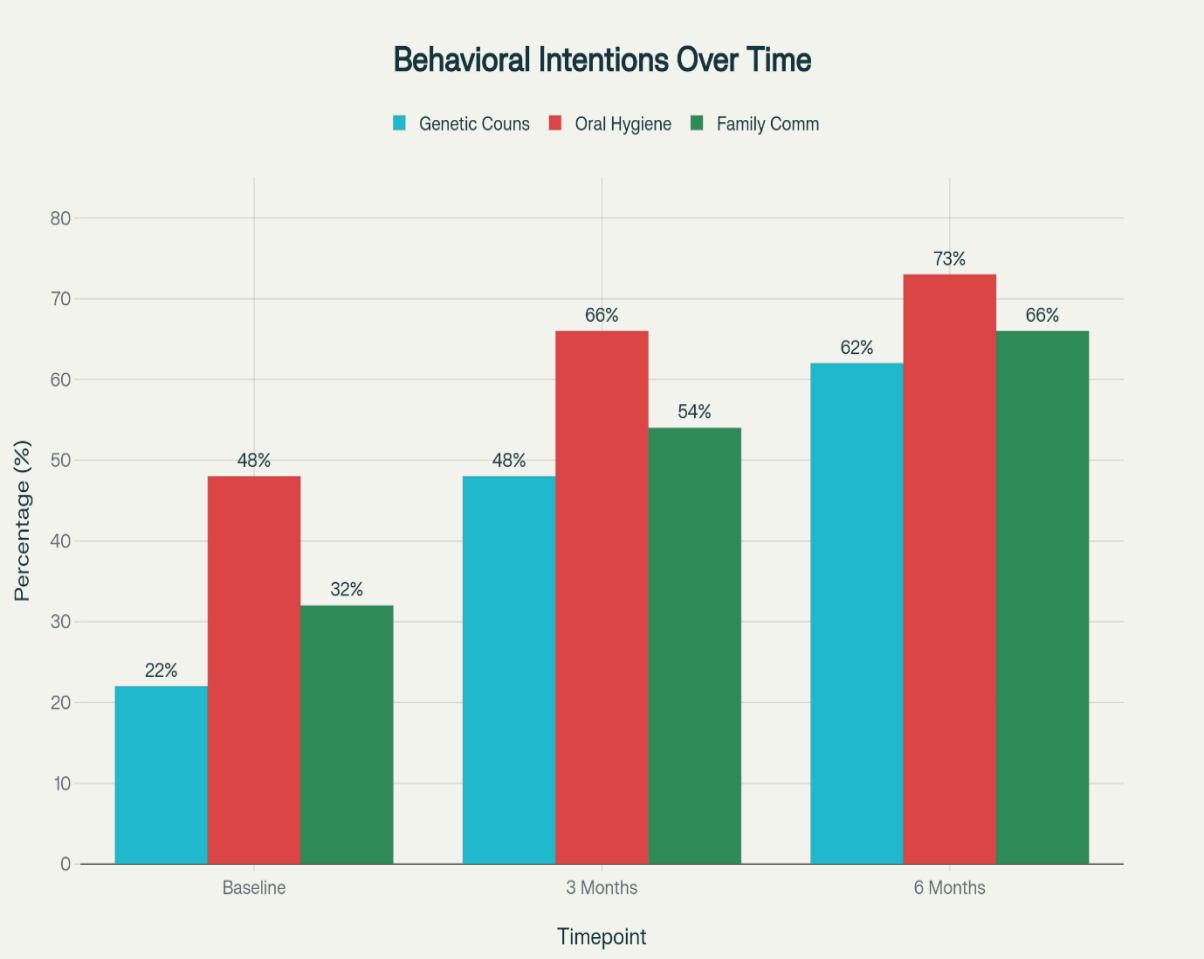

Fig.1: Behavioral Intentions Over Time Following Genetic and Dental Health Education Intervention.

DISCUSSION

This study, conducted at Government Dental College and Hospital, RIMS, Kadapa, demonstrates that a 20-minute genetic risk education intervention, incorporating environmental factors like bottled water usage, significantly enhances genetic knowledge (50% to 78%, $p<0.001$, Cohen's $d=1.1$), risk perception (3.1 to 4.4, $p<0.001$, Cohen's $d=0.8$), enamel erosion outcomes (BEWE: 3.2 to 2.7, $p=0.02$), and reduces frequent bottled water usage (55% to 38%, $p=0.01$) over six months [10, 15]. These findings align with primary care interventions that improve understanding of hereditary risks for conditions like caries, periodontal disease, and enamel defects, validating dental settings as viable platforms for genomic education [1, 8]. The Genetic Knowledge Scale and BEWE Index effectively captured these improvements, consistent with their established validity [10, 14]. In India, where genetic literacy and access to fluoridated water are limited, this intervention addresses critical health disparities for conditions such as amelogenesis imperfecta, oral cancer, and enamel erosion [2, 4, 7].

The transient increase in anxiety (HADS-A: 6.4 to 7.0, $p=0.04$, resolving to 5.9, $p=0.03$) reflects adaptive responses to genetic and environmental risk disclosure, subsiding with clear, patient-centered information [12, 15]. This is particularly relevant for enamel erosion, where genetic predispositions and low-fluoride bottled water use may heighten initial concern but foster resilience [2, 3]. Stable depression scores (HADS-D: 5.1 ± 1.3, $p=0.50$) underscore the intervention's psychological safety [12]. The correlations between knowledge and behavioral intentions ($r=0.60$, $p<0.01$), BEWE score reduction ($r=-0.35$, $p=0.03$), and reduced bottled water usage ($r=-0.40$, $p=0.01$) support the Health Action Process Approach (HAPA) model, where enhanced understanding drives actions like seeking genetic counseling (22% to 62%), improving oral hygiene (48% to 73%), and favoring fluoridated water [13]. These outcomes align with studies linking environmental risk awareness to preventive behaviors for caries and erosion [3, 11].

The 34% increase in intention to share family history (32% to 66%, $p<0.001$) could facilitate early detection of conditions like dentinogenesis imperfecta and enamel erosion, enhancing familial risk assessment [5]. In resource-limited settings like India, this low-cost, brief intervention leverages routine dental visits to improve accessibility, addressing barriers to genetic education [7, 9]. However, challenges such as staff training and patient literacy must be addressed to ensure scalability [9, 16]. Dental settings offer distinct advantages over primary care by embedding education within oral health workflows, but tailored curricula are needed to sustain impact [8]. Future multi-center trials should explore sustained behavior changes, objective measures (e.g., actual genetic counseling uptake, fluoride levels in water), and applicability across diverse populations to refine precision dentistry paradigms [6, 9].

Limitations

This single-center study at Government Dental College and Hospital, RIMS, Kadapa, may limit generalizability to other populations [5]. Consecutive recruitment may introduce selection bias, favoring patients with pre-existing interest in genetic risks [6]. The 7.5% dropout rate, though low, could skew results toward more engaged participants. Self-reported outcomes, such as bottled water usage, risk social desirability bias, and the six-month follow-up may not capture sustained behavioral or clinical changes [11]. Future studies should incorporate objective measures (e.g., counseling attendance, water fluoride assays) and extended follow-ups to validate long-term efficacy [6].

CONCLUSION

This brief genetic risk education intervention, integrating environmental factors like bottled water usage, significantly enhances knowledge, improves enamel erosion outcomes, supports psychological adaptation, and promotes preventive behaviors. Piloted at Government Dental College and Hospital, RIMS, Kadapa, it provides a scalable blueprint for embedding genomic education in dental practice, advancing precision dentistry and health equity. Multi-center trials with objective measures and longer follow-ups are essential to confirm its translational potential across diverse settings.

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