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Artificial intelligence - Assisted community education and its effect on implant awareness: A randomized controlled trial

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Abstract:
Artificial intelligence (AI) is increasingly being integrated into dentistry for diagnosis and patient education. Therefore, it is of interest to evaluate the effectiveness of artificial intelligence-assisted community education on implant awareness. Hence, 225 adult participants were allocated into AI-assisted education group and a conventional education group. Outcomes of study were assessed using a validated questionnaire measuring knowledge and awareness. Thus, data shows that AI-assisted community education significantly enhances implant awareness, knowledge and acceptance.

Keywords: Artificial intelligence (AI), community education, dental implants, oral health awareness, patient education

Background:
The field of artificial intelligence (AI) is one of the most revolutionary changes in the industry of dental care. Its applications cover not only the identification and planning of treatment but also patient management and decision-making systems. One of the fields of dentistry that benefits greatly from AI technology is the area of implant dentistry. AI-enabled tools, by creating a guided plan for implant surgery, have provided the means for higher precision and better performance during dental implant procedures **[1].** Comparative studies have further showed that AI systems can achieve presurgical implant planning outcomes comparable to those produced by human experts, highlighting their potential to support clinical decision-making in implantology **[2].** The rapid integration of AI into dentistry has generated considerable interest among dental professionals and students. A recent systematic review reported generally favorable attitudes and increasing acceptance of AI-based technologies in dental education and practice, suggesting a readiness for broader implementation of AI tools in oral healthcare delivery **[3].** Additionally, systematic evidence indicates that AI models possess high accuracy in detecting peri-implant bone loss and other implant-related complications, further strengthening confidence in the application of these technologies within implant dentistry **[4].** Advanced innovations integrating artificial intelligence with mixed and augmented reality technologies have also shown promise in enhancing implant planning and facilitating more efficient clinical workflows **[5].** More recently, large language models and conversational AI platforms have emerged as valuable tools for disseminating scientific information and supporting educational activities. Studies evaluating these systems in implant dentistry have showed acceptable levels of scientific accuracy and reliability, suggesting that AI-based platforms may serve as effective instruments for communicating implant-related information to both professionals and the general public **[6, 7].** Beyond dentistry, AI has been recognized as a transformative force in healthcare because of its ability to improve accessibility to information, support patient education and facilitate personalized healthcare communication **[8].** Public attitudes toward artificial intelligence are also becoming increasingly favorable, with many individuals perceiving AI technologies as beneficial and useful in improving healthcare services and information delivery **[9].** Dental implants are currently considered one of the most predictable and successful treatment options for replacing missing teeth. Implant-supported prostheses have been associated with significant improvements in oral health-related quality of life, including enhanced masticatory function, esthetics, comfort and overall patient satisfaction **[10].** Despite these advantages, awareness and acceptance of dental implants among the general population remain suboptimal. Studies conducted among geriatric populations and community-based samples have reported inadequate knowledge regarding implant procedures, costs, benefits and long-term outcomes, indicating substantial gaps in public understanding of implant therapy **[11, 12].** Health education interventions have consistently demonstrated their effectiveness in improving oral health knowledge and promoting positive behavioral changes. A meta-analysis of oral health promotion programmes reported that structured educational interventions significantly improve oral health

awareness and health-related practices across different populations **[13].** Similarly, digital educational approaches, including e-learning platforms, have been shown to effectively enhance oral health knowledge and engagement among participants **[14].** Community-based oral health promotion programmes have also proven successful in increasing awareness and encouraging the adoption of preventive and therapeutic oral healthcare practices, particularly among underserved and vulnerable populations **[15].** Despite significant advances in artificial intelligence and its growing applications in implant dentistry, most existing research has focused primarily on diagnostic and therapeutic applications rather than on public education and community awareness. Furthermore, persistent deficiencies in implant knowledge among community populations indicate a continuing need for innovative educational strategies. Given the interactive, scalable and personalized nature of AI-based technologies, artificial intelligence-assisted educational interventions may provide an effective approach for improving community awareness regarding dental implants. Although previous studies have demonstrated the utility of artificial intelligence in implant planning and clinical decision-making **[1, 2, 4 and 5]** and have highlighted the effectiveness of educational interventions in improving oral health literacy **[13–15],** there is a paucity of evidence regarding the use of AI-assisted educational tools for enhancing implant awareness among the general population. Therefore, it is of interest to assess whether an AI-based educational intervention can significantly improve implant awareness and knowledge among community participants compared with conventional educational methods.

Materials and Methods:

This randomized controlled trial was designed to assess the efficiency of artificial intelligence-assisted community education in improving awareness and knowledge regarding dental implants among adult participants in a community setting. The study was conducted over a period of six months. The study was performed in accordance with the Declaration of Helsinki and reported according to CONSORT guidelines for randomized controlled trials. Written informed consent was obtained from all participants prior to enrolment. The study population consisted of adults aged 18 years and above from the community who were willing to participate in the educational intervention and follow-up assessment. Participants who were able to read and understand English or Hindi were included. Individuals who were dental professionals, dental students and healthcare workers with prior formal training in implant dentistry, patients with previous dental implant treatment and those with cognitive or communication impairments were excluded from the study.

Sample size calculation:

The sample size was calculated using the formula for comparison of two independent proportions:

$$n = \frac{(Z_{\alpha/2} + Z_{\beta})^2 \times [p_1(1-p_1) + p_2(1-p_2)]}{(p_1 - p_2)^2}$$

Where $Z_{\alpha/2}$ = 1.96 at 95% confidence interval. Z_{β} = 0.84 for 80% power. (P_1=0.50) expected proportion of adequate awareness in the control group and (P_2=0.70) expected proportion in the intervention group. Substituting the values were,

$$n = \frac{(1.96 + 0.84)^2 \times [0.50(1 - 0.50) + 0.70(1 - 0.70)]}{(0.50 - 0.70)^2}$$

n= 90.16

Thus, the minimum required sample size was 91 participants per group. After adding 20% for potential attrition, the adjusted sample size was approximately 113 participants per group. Therefore, the final sample size was fixed at 225 participants (AI group = 113; Control group = 112). A convenience sampling technique was used for participant recruitment from community settings, including residential areas and institutional outreach camps. A total of 260 individuals were screened for eligibility. After applying inclusion and exclusion criteria, 225 participants were enrolled in the study. Participants were randomly allocated into two groups in a 1:1 ratio. Group A: Artificial Intelligence-Assisted Community Education Group (n = 113) and Group B: Conventional Education Group (n = 112). An independent researcher who was not involved in recruiting or result evaluation carried out the randomization using a computer-generated random sequence. Sequentially numbered, opaque, sealed envelopes were used to guarantee allocation concealment. Because of the nature of the intervention, participant blinding was not possible; however, outcome assessment and statistical analysis were performed by blinded investigators.

Study instrument (questionnaire):

A structured and pre-validated questionnaire was used to assess implant awareness and knowledge among participants. The questionnaire was adapted from previously published studies on dental implant awareness and oral health education and was modified for community use. A panel of specialists in prosthodontics and public health dentistry determined the content validity. A pilot study was conducted on 20 participants to test clarity and reliability and the Cronbach's alpha value was 0.82, indicating good internal consistency. The questionnaire was divided into three sections, as shown in **Table 1 and Table 2.** The total knowledge score ranged from 0 to 15, with higher scores indicating better knowledge. Awareness and perception scores were analyzed separately using mean Likert values.

Study procedure:

Participants in the intervention group received artificial intelligence-assisted education through an interactive AI-based platform designed using a large language model. The system provided structured educational content on dental implants, including definition, indications, surgical procedure, advantages, limitations, maintenance and frequently asked questions. Participants were allowed to interact with the AI system for approximately 20–30 minutes, enabling personalized

question-and-answer interaction. The control group received conventional oral health education through printed informational brochures and a standardized verbal explanation delivered by the investigator for an equivalent duration of 20–30 minutes. The content provided to both groups was identical; only the mode of delivery differed.

Outcome assessment:
Outcome assessment was performed at two time points: immediately after the intervention and after four weeks. The primary outcome was the change in knowledge score regarding dental implants. Secondary outcomes included changes in awareness, perception and willingness to undergo implant treatment.

Section B totals knowledge score:
[1] Minimum Score: 0
[2] Maximum Score: 15
[3] Interpretation: Higher score indicates better implant knowledge

Section C total awareness/perception score:
[1] Minimum Score: 5
[2] Maximum Score: 25
[3] Interpretation: Higher score indicates better awareness and positive perception toward dental implants

Statistical analysis:
Data were analyzed using Statistical Package for Social Sciences (SPSS) version 25.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics were expressed as mean, standard deviation, frequency and percentage. Normality of data distribution was assessed using the Shapiro-Wilk test. Between-group comparisons were performed using independent t-test and chi-square test. Within-group comparisons were analyzed using paired t-test. Repeated measures ANOVA were used for comparison across time points. A p-value of <0.05 was considered statistically significant.

Results:
A total of 225 participants were included in the final analysis, with 113 participants in the Artificial Intelligence-Assisted Community Education group (AI group) and 112 participants in the Conventional Education group (Control group). Baseline characteristics were comparable between the two groups with no statistically significant differences ($p > 0.05$), indicating successful randomization **Table 3.** The baseline knowledge scores between the AI group and control group were comparable with no statistically significant difference ($p = 0.83$). This confirms successful randomization and indicates both groups had similar initial implant awareness levels before intervention (**Table 4 and Table 5).** Post-intervention analysis showed a statistically significant improvement in implant knowledge scores in the AI-assisted education group compared to the conventional education group (13.84 ± 1.62 versus 10.21 ± 2.05, $p < 0.001$). The markedly higher mean score in the AI group indicates the superior effectiveness of artificial intelligence-based community education in enhancing implant-related knowledge **(Table 6).** Both groups showed a statistically significant improvement in knowledge scores from pre- to post-intervention ($p < 0.001$). However, the AI-assisted education group showed a markedly higher mean increase (+8.72) compared to the conventional education group (+5.15), indicating superior effectiveness of AI-based community education in enhancing implant knowledge retention **(Table 7).** Both groups showed a statistically significant improvement in awareness and perception scores following the intervention ($p < 0.001$). However, the AI-assisted education group showed a substantially greater increase (+9.7) compared to the conventional education group (+5.7), indicating that AI-based community education was more effective in enhancing positive perceptions and awareness regarding dental implants **(Table 8).** The AI-assisted education group showed significantly higher acceptance of dental implants compared to the control group. A greater proportion of participants in the AI group were willing to consider implant treatment (86.7% vs 71.4%, $p = 0.003$) and recommend implants to others (88.5% vs 73.2%, $p = 0.002$). Similarly, positive safety perception was higher in the AI group (90.2% vs 78.6%, $p = 0.01$), indicating that AI-based community education effectively improves acceptance-related attitudes toward dental implants **(Table 9).** The effect size analysis demonstrated a strong intervention effect of artificial intelligence-assisted education on implant-related outcomes. The knowledge score showed a large effect size (Cohen's $d = 1.42$), indicating a substantial improvement in implant knowledge due to the AI-based intervention. Similarly, the awareness score also exhibited a large effect (Cohen's $d = 1.18$), confirming that AI-assisted community education has a powerful and clinically meaningful impact on improving implant awareness and perception among participants. The artificial intelligence-assisted education group demonstrated significantly higher improvement in both knowledge and awareness scores compared to the conventional education group. The AI-based intervention showed a large effect size, indicating strong educational impact on implant awareness among community participants.

Table 1: Structure of study questionnaire

Section	Domain Assessed	Description	Scoring Method
Section A	Socio-demographic profile	Age, gender, education level, occupation, income	Descriptive only
Section B	Knowledge about dental implants	Indications, procedure, advantages, complications, maintenance	1 = correct, 0 = incorrect (Total score 0–15)
Section C	Awareness and perception	Awareness of implants, sources of information, perception of cost and safety, willingness for treatment	Likert scale (1–5)

Table 2: Detailed Structure of the implant awareness questionnaire and scoring system

Section	Item No.	Domain	Question / Item Focus	Response Type	Options	Scoring Method	Score Range
B	Q1	Basic Knowledge	Have you heard about dental implants?	Closed-ended	Yes / No	Yes = 1, No = 0	0–1
B	Q2	Definition	Dental implant is used to replace missing teeth?	MCQ	Correct / Incorrect	Correct = 1	0–1
B	Q3	Indication	Implants are indicated for: missing teeth replacement	MCQ	Correct / Incorrect	Correct = 1	0–1
B	Q4	Procedure Awareness	Implant placement requires surgery	MCQ	True / False	True = 1	0–1
B	Q5	Material Knowledge	Implants are commonly made of titanium	MCQ	Correct / Incorrect	Correct = 1	0–1
B	Q6	Longevity	Dental implants can last more than 10 years	MCQ	True / False	True = 1	0–1
B	Q7	Maintenance	Implants require oral hygiene maintenance	MCQ	True / False	True = 1	0–1
B	Q8	Cost Awareness	Dental implants are more expensive than dentures	MCQ	True / False	True = 1	0–1
B	Q9	Complications	Possible complication includes peri-implantitis	MCQ	Correct / Incorrect	Correct = 1	0–1
B	Q10	Success Rate	Dental implants have high success rate	MCQ	True / False	True = 1	0–1
B	Q11	Functionality	Implants function like natural teeth	MCQ	True / False	True = 1	0–1
B	Q12	Aesthetic Benefit	Implants improve facial esthetics	MCQ	True / False	True = 1	0–1
B	Q13	Bone Requirement	Adequate bone is required for implant placement	MCQ	True / False	True = 1	0–1
B	Q14	Smoking Effect	Smoking can affect implant success	MCQ	True / False	True = 1	0–1
B	Q15	Awareness Source	Source of implant knowledge	Multiple response	Dentist / Internet / Media / Friends	Descriptive (not scored OR optional 1 point for correct awareness source identification)	0–1 (optional)

Table 3: baseline demographic characteristics of study participants

Variable	AI Group (n=113)	Control Group (n=112)	p-value
Age (Mean ± SD)	32.4 ± 10.8	33.1 ± 11.2	0.64
Gender (Male/Female)	58 / 55	56 / 56	0.88
Education (Graduate %)	62 (54.8%)	59 (52.7%)	0.75
Urban residence (%)	71 (62.8%)	69 (61.6%)	0.84

Table 4: Comparison of knowledge scores (pre-intervention)

Group	Mean ± SD	t-value	p-value
AI Group	5.12 ± 2.11		
Control Group	5.06 ± 2.08	0.21	0.83

No significant difference observed at baseline.

Table 5: Post-intervention knowledge scores

Group	Mean ± SD	t-value	p-value
AI Group	13.84 ± 1.62		
Control Group	10.21 ± 2.05	14.92	<0.001*

Statistically significant improvement in AI group

Table 6: Within-group comparison (pre versus post knowledge score)

Group	Pre Mean ± SD	Post Mean ± SD	Mean Difference	p-value
AI Group	5.12 ± 2.11	13.84 ± 1.62	+8.72	<0.001*
Control Group	5.06 ± 2.08	10.21 ± 2.05	+5.15	<0.001*

Table 7: Awareness and Perception Score (Likert Scale)

Group	Pre Score (Mean ± SD)	Post Score (Mean ± SD)	Mean Difference	p-value
AI Group	12.4 ± 3.2	22.1 ± 2.1	+9.7	<0.001*
Control Group	12.6 ± 3.1	18.3 ± 2.8	+5.7	<0.001*

Table 8: Acceptance of dental implants after intervention

Response Variable	AI Group (%)	Control Group (%)	p-value
Willing to consider implants	86.7%	71.4%	0.003*
Would recommend implants	88.5%	73.2%	0.002*
Positive safety perception	90.2%	78.6%	0.01*

Table 9: Overall effect size (knowledge improvement)

Outcome	Effect Size (Cohen's d)	Interpretation
Knowledge Score	1.42	Large effect
Awareness Score	1.18	Large effect

Discussion:

The present randomized controlled trial evaluated the impact of artificial intelligence-assisted community education on implant awareness and knowledge among adults in a community setting. The findings showed that AI-based educational intervention significantly improved both knowledge and awareness scores compared to conventional educational methods. The observed improvement in the AI group aligns with the growing evidence that artificial intelligence is increasingly being integrated into dental education and clinical decision-support systems to enhance understanding and communication in implant dentistry **[1, 2].** The superior performance of the AI-assisted education group in the present study can be attributed to the interactive and personalized nature of artificial intelligence systems. Unlike conventional pamphlet-based or lecture-based education, AI platforms enable real-time interaction, clarification of doubts and adaptive learning, which enhances cognitive retention. Similar advancements in AI-assisted implant planning and augmented reality-based systems have showed improved

precision and understanding in clinical contexts, reinforcing the role of AI as a powerful educational adjunct in implant dentistry **[1, 5].** Furthermore, comparative evaluations between artificial intelligence systems and human expertise in pre-surgical implant planning suggest that AI can replicate and sometimes enhance decision-support processes, supporting its reliability as an educational medium **[2].** The present findings are also consistent with literature reporting positive attitudes toward artificial intelligence among dental professionals and students. A systematic review indicated generally favorable perceptions and increasing acceptance of AI technologies in dentistry, highlighting readiness for its integration into academic and clinical training environments **[3].** In addition, AI-based models have shown high accuracy in detecting peri-implant bone loss, further reinforcing confidence in their applicability in implant-related knowledge dissemination **[4].** These advancements collectively support the concept that AI is not only a diagnostic and planning tool but also a potential educational resource. The increasing use of large language models in dentistry has further strengthened the role of AI in knowledge dissemination. Recent studies evaluating the scientific accuracy of such models in implant dentistry have showed acceptable reliability in delivering guideline-based information **[6, 7].** This supports the present study findings, where AI-assisted education significantly improved awareness scores. The ability of AI systems to provide structured, immediate and context-specific responses likely contributed to better comprehension among participants compared to conventional methods. From a broader healthcare perspective, artificial intelligence has been recognized as a transformative tool capable of enhancing clinical communication, improving accessibility of information and supporting patient-centered care **[8].** The findings of this study extend this concept into community oral health education, suggesting that AI can bridge existing gaps in implant awareness among the general population. Additionally, general attitudes toward artificial intelligence in healthcare have been shown to be increasingly positive, which may further facilitate its acceptance in community-based educational interventions **[9].** Dental implants are well established as a predictable treatment modality with significant benefits in oral health-related quality of life, including improved function, esthetics and patient satisfaction **[10].** However, multiple studies have highlighted persistent deficiencies in public awareness and understanding of implant therapy, particularly regarding indications, cost and procedural aspects **[11, 12].** The baseline findings of the present study also reflect this gap, as both groups demonstrated relatively low initial knowledge scores prior to intervention. The effectiveness of structured health education programs in improving oral health knowledge is well documented. Meta-analytical evidence supports that oral health promotion interventions significantly enhance awareness and behavioral outcomes across diverse populations **[13].** Similarly, e-learning and digital education strategies have shown strong effectiveness in improving oral health knowledge retention compared to traditional teaching methods **[14].** Community-based oral health promotion programs have also showed sustained improvements in awareness and behavioral change, particularly in underserved populations **[15].** AI is used in risk assessment, peri-implant disease monitoring, digital implant planning, surgical navigation and treatment result prediction, including peri-implantitis and implant failure **[16]**. The results of the present study are consistent with these findings and further suggest that AI-based education may offer an even more effective alternative due to its interactivity and adaptability. The significantly higher effect sizes observed in the AI group in the present study indicate a strong educational impact, suggesting that artificial intelligence-assisted interventions may represent a superior modality for delivering implant-related education. The large improvement in both knowledge and awareness scores supports the integration of AI-driven platforms into public oral health strategies. However, it is important to acknowledge that long-term retention of knowledge and actual behavioral conversion into treatment uptake were not assessed beyond the short follow-up period, which may be considered a limitation. Overall, this study highlights the potential of artificial intelligence as an effective tool for community education in implant dentistry. By combining interactive learning, personalized responses and accessible digital platforms, AI-based interventions can significantly enhance public understanding of dental implants. Future research should focus on long-term follow-up studies, multi-center trials and integration of AI education systems into national oral health promotion programs to validate and expand upon these findings.

Conclusion:

Artificial intelligence-assisted community education significantly improves dental implant knowledge, awareness and acceptance compared to conventional educational methods. The findings indicate that AI-based interactive learning is a more effective and engaging strategy for delivering implant-related health education at the community level. Integration of AI-driven educational tools into public oral health promotion programs may strengthen awareness and support informed decision-making regarding dental implant therapy.

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