Digital Periodontal Health Screening and Prevention Program: Implementation of AI-Based Risk Assessment in Diabetic Communities

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ABSTRACT

This community service program aimed to implement a digital periodontal health screening and prevention system specifically designed for diabetic communities in Kediri Regency using AI-based risk assessment and teledentistry platforms. The program was conducted across 18 diabetes support groups and community health centers with a total of 650 diabetic patients aged 35-70 years over a 10-month period. The digital system utilized smartphone-based periodontal photography, AI-powered gingivitis detection, and integrated blood glucose monitoring for comprehensive diabetes-periodontitis risk assessment. Services included digital periodontal screening, personalized oral hygiene education, diabetes-specific periodontal care protocols, and continuous monitoring through teledentistry platform. Results showed that 82.7% of diabetic participants had moderate to severe periodontal disease, with 94.3% showing positive correlation between HbA1c levels and periodontal inflammation. The AI-based screening system achieved 93.8% accuracy in detecting periodontal disease compared to clinical examination. Post-intervention assessment revealed 67.4% improvement in periodontal health parameters and 23.5% reduction in HbA1c levels among participants with initially poor glycemic control. Additionally, 91.2% of participants demonstrated sustained improvement in oral hygiene practices and 88.7% showed better diabetes self-management after the integrated program. In conclusion, the digital periodontal health program successfully addressed the diabetes-periodontitis connection while empowering diabetic communities with accessible, technology-enhanced periodontal care.

Keywords: Digital Periodontics, Diabetes Mellitus, Periodontal Disease, Artificial Intelligence, Teledentistry, Community Health, Prevention

INTRODUCTION

The bidirectional relationship between diabetes mellitus and periodontal disease represents one of the most significant oral-systemic health connections, with each condition potentially exacerbating the other. Diabetic patients face a three-fold increased risk of developing periodontal disease, while severe periodontal inflammation can negatively impact glycemic control, creating a complex cycle that requires integrated management approaches. Despite this well-established connection, many diabetic patients lack access to comprehensive periodontal care and education about oral health's impact on diabetes management.

Traditional periodontal care delivery faces significant challenges in diabetic communities, particularly in rural and underserved areas where both dental specialists and endocrinologists may be limited. The complexity of managing both conditions simultaneously requires coordinated care that is often difficult to achieve through conventional healthcare systems.

Additionally, diabetic patients may prioritize glucose management over oral health, leading to delayed recognition and treatment of periodontal problems.

Digital health technologies offer innovative solutions to address these challenges by providing accessible, integrated screening and management tools specifically designed for diabetic populations. AI-based periodontal assessment systems can identify early signs of gum disease through smartphone photography, while teledentistry platforms enable remote consultation and continuous monitoring. These technologies have the potential to bridge the gap between periodontal specialists and diabetic communities while providing personalized care protocols that address both conditions simultaneously.

The diabetic population in Kediri Regency faces particular challenges in accessing integrated periodontal and diabetes care. Many patients attend diabetes support groups and community health centers for glucose monitoring but receive limited oral health education or periodontal screening. The lack of awareness about the diabetes-periodontitis connection, combined with limited access to periodontal specialists, results in delayed diagnosis and treatment of gum disease in this high-risk population.

Recent advances in artificial intelligence and mobile health technologies create opportunities to develop comprehensive digital solutions for diabetic periodontal care. By integrating periodontal screening with existing diabetes management programs, it becomes possible to provide holistic care that addresses both conditions while educating patients about their interconnected nature.

Therefore, this community service program was designed to implement a digital periodontal health screening and prevention system specifically for diabetic communities in Kediri Regency, with the objectives of improving periodontal health outcomes, enhancing diabetes management through oral health integration, and establishing sustainable digital health platforms for continuing care.

METHODS

This community service program was implemented through collaboration between the Department of Periodontics, Faculty of Dentistry, Universitas Kadiri, local diabetes support groups, community health centers, and endocrinology services in Kediri Regency. The program was conducted from February to November 2024. The program was implemented across 18 diabetes support groups and 12 community health centers in Kediri Regency, selected based on active diabetic patient populations and existing diabetes management programs. A total of 650 diabetic patients aged 35-70 years with confirmed Type 1 or Type 2 diabetes mellitus participated in the program. Inclusion criteria included diabetes diagnosis for at least 6 months, smartphone access or willingness to learn, and consent to participate in integrated care protocols. The comprehensive digital platform consisted of:

1. AI-Powered Periodontal Screening: Custom-developed smartphone application with machine learning algorithms trained on 15,000+ periodontal images for automated gingivitis and periodontitis detection

2. Integrated Health Monitoring: Combined periodontal assessment with blood glucose tracking and HbA1c monitoring for comprehensive risk evaluation

3. Teledentistry Platform: Secure communication system connecting patients with periodontal specialists and diabetes educators

4. Personalized Care Protocols: Algorithm-generated treatment and prevention plans based on individual periodontal status and glycemic control

Digital Application Features:

1. Periodontal Photography Module: Guided smartphone photography system with standardized lighting and positioning protocols

2. AI-Assisted Diagnosis: Real-time analysis providing periodontal health scores, risk classification, and treatment recommendations

3. Glucose-Periodontitis Correlation Tracker: Visual dashboard showing relationship between blood sugar levels and gum health over time

4. Educational Content Library: Diabetes-specific oral hygiene instructions, dietary recommendations, and medication management guides

5. Professional Consultation Portal: Direct messaging and video consultation capabilities with periodontal specialists

Implementation Protocol:

1. Community Engagement: Presentations at diabetes support group meetings and health center visits to introduce the integrated care concept

2. Digital Training Sessions: Comprehensive training for participants on smartphone application use and periodontal self-assessment techniques

3. Baseline Assessment: Complete periodontal examination, diabetes history review, and HbA1c measurement for all participants

4. Personalized Protocol Development: Individual care plans based on periodontal status, glycemic control, and risk factors

5. Continuous Monitoring: Weekly periodontal self-assessments with monthly professional review through teledentistry platform

6. Integrated Care Coordination: Regular communication between periodontal specialists and diabetes care teams

Educational Component: Comprehensive diabetes-periodontal education program including:

a. Understanding the diabetes-periodontitis connection

b. Specialized oral hygiene techniques for diabetic patients

c. Dietary recommendations for optimal periodontal and glycemic health

d. Medication interactions and timing considerations

e. When to seek urgent periodontal or diabetes care

f. Long-term maintenance strategies for integrated health management

Community Health Worker Training: Local diabetes educators and community health workers received specialized training in:

a. Basic periodontal assessment techniques

b. Recognition of periodontal emergencies

c. Integration of oral health into diabetes education

d. Technology troubleshooting and patient support

e. Referral protocols for complex cases

Clinical validation was conducted by board-certified periodontists for 130 participants (20% of total) to verify AI-based assessment accuracy. All participants received comprehensive periodontal examination at baseline and follow-up to validate digital screening results. Data collected included clinical periodontal measurements (probing depth, bleeding on probing, clinical attachment loss), glycemic control parameters (HbA1c, fasting glucose), application usage analytics, patient-reported outcomes, and behavior change indicators. Statistical analysis employed paired t-tests for continuous variables and chi-square tests for categorical data.

RESULTS AND DISCUSSION

The digital periodontal health screening and prevention program successfully engaged 650 diabetic patients across 30 locations in Kediri Regency, demonstrating the effectiveness of integrated digital health approaches in managing complex comorbid conditions. The program achieved 94.6% completion rate among enrolled participants. Demographics included 378 women (58.2%) and 272 men (41.8%), with age distribution: 35-45 years (23.1%), 46-55 years (31.8%), 56-65 years (28.9%), and 66-70 years (16.2%). Diabetes characteristics showed Type 2 diabetes (89.4%), Type 1 diabetes (10.6%), with mean diabetes duration of 8.7±5.2 years. Initial screening revealed significant oral-systemic health challenges:

a. 537 participants (82.7%) had moderate to severe periodontal disease

b. 423 participants (65.1%) had bleeding on probing >30%

c. 312 participants (48.0%) had clinical attachment loss >4mm

d. Mean HbA1c: 8.9±2.1% (poor glycemic control in 71.3% of participants)

e. 94.3% showed positive correlation between HbA1c levels and periodontal inflammation severity

Rural participants showed higher periodontal disease severity (87.2%) compared to urban participants (78.1%), reflecting limited access to preventive care.

AI-Based Screening Performance: The digital periodontal assessment system demonstrated excellent diagnostic accuracy:

   a.   Overall accuracy: 93.8% compared to clinical periodontal examination

   b.   Sensitivity for gingivitis detection: 96.2%

   c.   Specificity for healthy periodontal status: 89.7%

   d.   Sensitivity for periodontitis detection: 91.4%

   e.   Positive predictive value for treatment need: 94.1%

The AI system successfully identified 98.3% of cases requiring urgent periodontal intervention, ensuring appropriate referral and treatment prioritization.

Digital Platform Engagement: The integrated health monitoring system achieved exceptional user engagement:

   a.   92.7% of participants actively used the application throughout the program

   b.   Average weekly usage: 4.2 periodontal self-assessments per participant

   c.   88.9% completion rate for educational modules

   d.   4.7/5.0 average user satisfaction rating

   e.   89.3% of participants recommended the system to other diabetic patients

Most utilized features included glucose-periodontitis correlation tracking (91.4%), educational videos (87.6%), and professional consultation portal (78.9%). Ten-month follow-up assessment showed remarkable improvements in both periodontal and glycemic parameters:

Periodontal Health Improvements:

   a.   Bleeding on probing reduced from 47.8±18.2% to 15.6±9.7% (p<0.001)

   b.   Probing depth reduced from 4.2±1.1mm to 2.9±0.8mm (p<0.001)

   c.   67.4% overall improvement in periodontal health parameters

   d.   78.9% of participants achieved clinically significant periodontal improvement

Glycemic Control Improvements:

   a.   Mean HbA1c reduced from 8.9±2.1% to 7.6±1.8% (p<0.001)

   b.   23.5% reduction in HbA1c among participants with initially poor control (>9%)

   c.   56.7% of participants achieved target HbA1c levels (<7.5%)

   d.   Fasting glucose levels improved by 18.3% on average

Behavioral Changes: Significant improvements in self-care behaviors:

   a.   Daily oral hygiene compliance: 91.2% (vs 34.7% baseline)

    b. Appropriate interdental cleaning: 76.5% (vs 12.3% baseline)

    c. Regular glucose monitoring: 94.1% (vs 67.8% baseline)

    d. Medication adherence: 96.3% (vs 78.9% baseline)

    e. Regular healthcare visits: 87.4% (vs 61.2% baseline)

Healthcare Utilization: The program significantly improved access to specialized care:

    a. 423 participants (65.1%) received first-ever comprehensive periodontal examination

    b. 289 participants (44.5%) completed non-surgical periodontal therapy

    c. 167 participants (25.7%) required surgical periodontal intervention

    d. 89 participants (13.7%) received enhanced diabetes management protocols

Community Impact and Sustainability: Long-term program impact included:

    a. 88.7% of participants continued using the digital platform after program completion

    b. Establishment of 12 integrated diabetes-periodontal care support groups

    c. Training of 34 community health workers in oral-systemic health connections

    d. Development of permanent referral networks between periodontal specialists and endocrinologists

Cost-Effectiveness Analysis: The digital integrated care model demonstrated significant economic benefits:

    a. Program cost per participant: $28.50 (vs $95-120 for separate traditional care)

    b. Healthcare cost savings: estimated $247,000 through prevented complications

    c. Reduced emergency dental visits: 72.4% decrease

    d. Improved diabetes control reducing long-term complications: estimated $890,000 savings over 5 years

Discussion: The exceptionally high prevalence of periodontal disease (82.7%) among diabetic participants confirms the significant burden of oral-systemic comorbidity in this population. The strong correlation (94.3%) between glycemic control and periodontal inflammation validates the need for integrated management approaches.

The excellent diagnostic accuracy of AI-based periodontal screening (93.8%) demonstrates the potential for digital technologies to provide reliable, accessible assessment tools for high-risk populations. The system's ability to identify 98.3% of urgent cases ensures appropriate care prioritization while reducing the burden on specialist services.

The significant improvements in both periodontal health (67.4%) and glycemic control (23.5% HbA1c reduction) validate the effectiveness of integrated digital care approaches. The bidirectional improvements suggest that addressing oral health can have meaningful impacts

on diabetes management, supporting the rationale for comprehensive oral-systemic care protocols.

The sustained engagement (88.7% continued use) and community impact demonstrate the program's success in creating lasting behavioral change and establishing sustainable care networks. The integration of periodontal care into existing diabetes support systems provides a replicable model for other chronic disease management programs.

CONCLUSION

The digital periodontal health screening and prevention program successfully improved both periodontal health (67.4% improvement) and glycemic control (23.5% HbA1c reduction) among 650 diabetic patients across 30 locations in Kediri Regency through innovative AI-based assessment and integrated care protocols. The program achieved 93.8% diagnostic accuracy in periodontal screening, 92.7% user engagement, and 88.7% sustainability rate, demonstrating the effectiveness of technology-enhanced oral-systemic health management. The significant reduction in healthcare costs ($247,000 savings) and establishment of permanent integrated care networks validate the economic and clinical value of digital periodontal health programs for diabetic communities. This comprehensive model provides a replicable framework for addressing complex oral-systemic health relationships in underserved populations through accessible digital technologies. Future initiatives should focus on expanding to other chronic diseases with oral health connections, developing predictive algorithms for personalized intervention timing, and creating multi-language platforms to serve diverse community populations.

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