

Article

# Development and Implementation of Personalized Primary Prevention Programs for Early Childhood Caries at the Outpatient Stage

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**Abstract:** This scientific article examines in detail the concept of individualization of preventive care in pediatric dentistry through the development and implementation of personalized primary caries prevention programs at the outpatient clinic stage. The authors substantiate that standard preventive approaches often fail to consider the unique risk factor profile of a particular family, which reduces their overall efficacy. The paper describes in detail the methodology and stages of a two-year clinical study involving one hundred and twenty children aged twelve to thirty-six months. An algorithm for stratifying patients by caries risk levels based on the assessment of hygiene status, dietary habits and microbiological markers is demonstrated. The results of a comparative analysis are presented, proving that a personalized approach, including customized selection of fluoride dosages and frequency of clinical applications, provides a 74.4% reduction in caries intensity increment. The high clinical efficacy of the programs regarding the stabilization of focal enamel demineralization lesions in primary teeth was recorded. In conclusion, the authors formulate a comprehensive medico-social and economic effect for practical healthcare.

**Keywords:** personalized dentistry, early childhood caries, primary prevention, outpatient stage, risk factors

## 1. Introduction

The high prevalence and severity of early childhood caries (ECC) has been a focus of attention for researchers and practitioners for many years. Despite the constant refinement of approaches to hygiene education, standard preventive programs implemented at the population or group level often demonstrate limited effectiveness in young children [1]. A key drawback of traditional approaches is their uniformity: they offer generic recommendations for care and nutrition, ignoring the unique nature of cariogenic risk factors in each individual family [2]. The current development of medicine necessitates a transition to a personalized model, where the treatment and preventive process is built around the patient's individual biological and behavioral profile. In pediatric dentistry, outpatient clinics are an ideal platform for implementing this concept, as they allow for continuous monitoring of a child's health, beginning in the first months of life [3].

The development of personalized primary prevention programs is based on thorough risk mapping, including an assessment of sociobehavioral, dietary, hygiene, and clinical parameters. This approach not only identifies hidden triggers of the pathological process (for example, frequent snacking on hidden sugars or the latent transmission of cariogenic microflora from parents) but also flexibly adapts the intensity

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of medical intervention. Instead of passively waiting for hard tissue destruction, individualized prevention aims to proactively manage the oral microbiome and enhance the enamel resistance of primary teeth during critical periods of its maturation [4].

Despite the recognized importance of early prevention, a significant challenge in pediatric dentistry remains the development of preventive strategies that correspond to the individual cariogenic risk profile of each child. Standardized preventive protocols may not adequately account for differences in oral hygiene, dietary behavior, family practices, microbiological conditions, and other factors contributing to early childhood caries [5]. Therefore, there is a need to evaluate whether risk-based personalized preventive programs can provide greater clinical effectiveness than conventional standardized preventive care in outpatient pediatric dentistry [6].

The aim of this study was to develop and evaluate the clinical effectiveness of personalized primary prevention programs for early childhood caries implemented at the outpatient stage. The study specifically sought to stratify young children according to their individual caries risk, develop differentiated preventive protocols for different risk categories, and compare their clinical effectiveness with standard preventive care over a two-year observation period [7].

It was hypothesized that individualized preventive programs based on preliminary caries-risk assessment would result in a lower increase in caries intensity, improved oral hygiene indicators, and more favorable outcomes of initial enamel demineralization compared with standard preventive measures [8].

## 2. Materials and Methods

To develop and evaluate the clinical effectiveness of differentiated primary prevention programs in outpatient settings, we conducted a two-year randomized controlled trial. The study included 120 children aged 12 to 36 months and their legal guardians. The study methodology consisted of three sequential stages. The first stage involved a detailed assessment of dental and behavioral status using a specially developed risk map. The map included questions on feeding patterns (nighttime feedings with carbohydrate formulas), home hygiene practices, and the mother's level of hygiene literacy. During the clinical examination, oral hygiene was assessed using the Visual Plaque Index (VPI), and the severity of dental damage was recorded using the KPI (where "k" stands for carious, "p" for filled, and "u" for extracted primary teeth). Based on the collected data, each child was assigned to one of three caries risk categories: low, moderate, or high.

The second stage of the methodology involved dividing the participants into two equal groups. The control group (n=60) received a standard preventive care package, regulated by the clinic's basic protocols (a one-time hygiene instruction and a checkup every six months). The study group (n=60) implemented personalized preventive programs. For low-risk patients, the program consisted of training parents in manual skills and prescribing a rice-grain-sized amount of 1000 ppm fluoride toothpaste twice daily. For the moderate-risk group, the frequency of visits was increased to four times per year, dietary adjustments were added (elimination of the "bottleneck" factor), and professional application of 5% fluoride varnish twice a year was added. For high-risk patients, a highly intensive protocol was developed: monthly monitoring, individual motivational training sessions for parents, professional teeth cleaning and fluoride varnish applications four times a year, and the use of specialized gels based on amorphous calcium phosphate. Evaluations of dental status dynamics in all groups were conducted at 12 and 24 months from the start of the study.

The primary outcome of the study was the change in caries intensity during the 24-month follow-up period. Secondary outcomes included changes in oral hygiene status, assessed using the Visual Plaque Index (VPI), and the clinical dynamics of initial enamel

demineralization lesions. These indicators were evaluated to compare the effectiveness of personalized risk-based prevention with the standard preventive approach.

Participants in the study group received preventive interventions according to their assigned caries-risk category, whereas participants in the control group continued to receive the standard preventive care provided by the outpatient clinic. Clinical assessments were performed at baseline and during the follow-up period, with final comparative evaluation conducted after 24 months. This design made it possible to assess both the overall preventive effect and the effectiveness of differentiated interventions according to individual caries risk.

The collected clinical data were subjected to comparative statistical analysis. Quantitative indicators were summarized using appropriate descriptive statistics, and differences between the study and control groups were evaluated to determine the clinical effectiveness of the personalized prevention program. Statistical significance was considered at  $p < 0.05$ .

### 3. Results

An analysis of the two-year monitoring results demonstrated the significant clinical validity of the developed individualized algorithms. A high cariogenic risk level was initially recorded in 43.3% of children in the study group, moderate in 41.7%, and low in 15.0%, indicating an unfavorable initial epidemiological situation. However, thanks to flexible risk factor management and high parental engagement, a significant improvement was achieved in the study group by the end of the study: the visible plaque index (VPI) decreased by 2.8 times, indicating a satisfactory level of home hygiene [9].

At the final examination after 24 months, the average increase in dental caries intensity (KPU index) in the study group was only  $0.38 \pm 0.07$ , while in the control group, which used the standard approach, this indicator reached  $1.48 \pm 0.19$  ( $p < 0.05$ ). Thus, the clinical effectiveness of the developed personalized programs in the form of a reduction in caries growth was 74.4% [10]. Of particular significance is the fact that among children in the study group with a high initial risk, who had foci of initial demineralization in the white spot stage at the beginning of the study, complete remineralization of the enamel and restoration of its optical properties occurred in 48.3% of cases. In contrast, in the control group, in 78.3% of children with initial changes, the pathological process transformed into planar or deep caries, requiring invasive preparation and filling, in some cases under general anesthesia [11].

The comparative results therefore demonstrated a more favorable clinical course in children receiving personalized preventive care than in those receiving the standard preventive protocol. After 24 months, the increase in caries intensity was substantially lower in the study group, with a mean value of  $0.38 \pm 0.07$  compared with  $1.48 \pm 0.19$  in the control group ( $p < 0.05$ ). This corresponded to a 74.4% reduction in caries increment associated with the personalized prevention program [12].

The results also demonstrated improvements beyond the reduction in caries increment. The decrease in the Visual Plaque Index indicated an improvement in home oral hygiene, while the observed remineralization of initial white-spot lesions among high-risk children demonstrated the potential clinical value of intensive risk-based preventive interventions. In contrast, progression of initial lesions to more advanced forms of caries was considerably more frequent among children receiving standard preventive care [13].

### 4. Discussion

Summarizing the obtained data, it can be stated that the implementation of personalized primary prevention programs helps overcome the main barrier of traditional pediatric dentistry: families' low adherence to standard dental recommendations. Dividing patients into risk groups allows the dentist to rationally

allocate resources during outpatient visits, focusing maximum attention and professional interventions on the most vulnerable children. Personalized home care and dietary regimens transform parents' passive attitudes into conscious preventive behavior. Outpatient care, refocused from the treatment of complications to individualized health management, has the potential to radically change the structure of dental morbidity in children [14].

The findings of the present study demonstrate that a personalized, risk-based approach to primary prevention can provide substantial clinical advantages over standardized preventive care in young children. The 74.4% reduction in caries increment observed in the study group indicates that differentiation of preventive measures according to individual cariogenic risk may substantially improve the effectiveness of outpatient prevention. Rather than applying an identical preventive protocol to all children, risk stratification makes it possible to adjust the frequency and intensity of professional interventions according to the specific needs of each patient [15]. The improvement in oral hygiene status further supports the effectiveness of the personalized approach. The 2.8-fold decrease in the Visual Plaque Index observed during follow-up suggests that individualized preventive programs may positively influence not only clinical outcomes but also everyday oral hygiene practices. An important component of the personalized program was active parental involvement through practical hygiene instruction, motivational training, and individualized dietary recommendations. Since children aged 12–36 months depend substantially on their caregivers for oral hygiene and dietary practices, parental participation represents an important component of preventive management in this age group.

Another clinically important finding was the favorable outcome observed among high-risk children with initial enamel demineralization. Complete remineralization and restoration of the optical properties of enamel were recorded in 48.3% of children with initial white-spot lesions in the study group. In contrast, progression toward more advanced carious lesions was observed in 78.3% of children with initial changes in the control group. These findings indicate the potential importance of identifying early non-cavitated lesions and initiating intensive individualized preventive and remineralizing interventions before irreversible destruction of dental hard tissues occurs. From a clinical perspective, the results support the integration of caries-risk assessment into routine outpatient pediatric dental practice. Preliminary stratification into low-, moderate-, and high-risk categories may help clinicians determine appropriate recall intervals and select the necessary intensity of preventive interventions. In the present study, preventive measures ranged from parental hygiene education and regular use of fluoride toothpaste in low-risk children to more frequent professional monitoring, fluoride varnish application, professional cleaning, and remineralizing interventions in children with higher cariogenic risk.

Several limitations should be considered when interpreting the findings. The study included 120 children aged 12–36 months and was conducted within an outpatient clinical setting; therefore, the findings should be generalized to broader pediatric populations with caution. In addition, the follow-up period was limited to 24 months. Further multicenter studies involving larger samples and longer observation periods would be useful for evaluating the long-term sustainability and broader applicability of personalized caries-prevention programs. Future studies may also examine the relative contribution of individual components of the preventive program to determine which interventions provide the greatest clinical benefit for each caries-risk category.

## 5. Conclusions

The study demonstrates that personalized primary prevention programs implemented at the outpatient stage can substantially improve the prevention and management of early childhood caries. Individual stratification of children according to

cariogenic risk enables the frequency of follow-up visits, intensity of professional preventive procedures, remineralizing therapy, and home-care recommendations to be adapted to each child's clinical needs. Over the 24-month observation period, the personalized preventive approach was associated with a **74.4% reduction in caries increment** compared with standard preventive care, while complete remineralization of initial white-spot lesions was achieved in **48.3% of high-risk children** receiving individualized interventions. These findings support the incorporation of personalized caries-risk assessment, regular clinical monitoring, individualized oral-hygiene instruction, dietary modification, fluoride-based prevention, and active parental involvement into routine outpatient pediatric dental practice. The expected medical and social impact includes improved oral health, preservation of the anatomical integrity of primary teeth, prevention of chewing and speech-related complications, and development of sustainable oral-health practices within families. From an economic perspective, widespread implementation of personalized prevention programs may reduce the need for costly dental treatment under general anesthesia by approximately **75–80%**, decrease the consumption of restorative materials, and enable more efficient allocation of pediatric dentists' working time toward preventive and outpatient care. Overall, personalized primary prevention represents a clinically promising approach for shifting pediatric dentistry from the treatment of established disease toward early risk identification, prevention, and preservation of primary tooth structure; however, larger studies with longer follow-up periods are recommended to confirm its long-term effectiveness, economic benefits, and broader applicability.

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