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ORIGINAL RESEARCH

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Comparative evaluation of visual-tactile examination and near-infrared transillumination in the diagnosis of dental caries in children aged 5–9 years

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Abstract

Background: Near-infrared light transillumination (NILT) has been proposed as a radiation-free alternative to traditional visual-tactile (VT) examination, yet comparative evidence in pediatric populations remains limited. To compare the detection rates of dental carious lesions using NILT (DIAGNOcam) and VT methods in children aged 5–9 years, and to explore potential associations between dietary habits and caries indices. **Methods**: A cross-sectional study was conducted on 185 children (89 girls, 96 boys; mean age 7.2 $\pm$ 1.4 years) attending routine dental check-ups. Each participant underwent both VT and NILT examinations performed by two calibrated examiners (κ = 0.86 intra-; κ = 0.82 inter-examiner reliability). Statistical analyses included the Wilcoxon signed-rank test, McNemar's test, Cohen's κ, and Spearman's correlation. Radiographs were excluded in alignment with the As Low As Reasonably Achievable (ALARA) principle. **Results**: NILT identified significantly more carious lesions than VT in both dentitions Decayed, Missing, and Filled Teeth (permanent dentition) (DMFT): 1.38 $\pm$ 1.31 *vs.* 0.79 $\pm$ 1.11, $p < 0.001$; decayed, missing, and filled teeth (primary dentition) (dmft): 4.68 $\pm$ 2.53 *vs.* 4.51 $\pm$ 2.52, $p < 0.001$. Agreement between methods was moderate (κ = 0.71). Weak but significant associations were observed between juice consumption and dmft indices (ρ = 0.195, p = 0.008). **Conclusions**: NILT demonstrated a higher detection rate for early enamel lesions compared with VT, particularly on interproximal surfaces. While not a replacement for radiographs in diagnosing deeper lesions, NILT represents a valuable non-invasive adjunct. Dietary findings were exploratory and require longitudinal confirmation.

Keywords

Dental caries in children; Caries diagnosis; Visual-tactile examination; Near-infrared light transillumination; DIAGNOcam; Minimally invasive dentistry

1. Introduction

Early and accurate diagnosis of dental caries is a cornerstone of minimally invasive dentistry (MID), particularly in pediatric patients with primary or mixed dentition. Children are especially susceptible to rapid caries progression due to the thinner enamel and dentin of primary teeth. Early identification of lesions is therefore essential to prevent cavitation, minimize the need for restorative treatment, and improve long-term oral health outcomes [1–3]. Dental caries is a multifactorial, biofilm-mediated disease resulting from the interaction among dietary sugars, cariogenic bacteria, susceptible tooth surfaces, and time. The classical triad proposed by Keyes described the interplay of diet, host, and microorganisms as the foundation of caries development [4]. Touger-Decker and Van Loveren later expanded this model by incorporating plaque accumulation, tooth susceptibility, and the frequency and duration of acid exposure [5]. Additional modifying factors including fluoride exposure, salivary flow and composition, oral hygiene habits, and socioeconomic status further influence caries risk and progression [6–8]. The visual-tactile (VT) examination remains the most common clinical approach for caries detection because it is simple, inexpensive, and non-invasive [9, 10]. However, VT has limited sensitivity for detecting early enamel and interproximal lesions, especially before cavitation occurs [11]. Radiographic methods such as bitewing radiographs offer higher diagnostic accuracy but involve ionizing radiation, which restricts their routine use in children [12, 13]. Near-infrared light transillumination (NILT) has recently emerged as a radiation-free imaging technique capable of visualizing early enamel and dentin demineralization. Devices such as the DIAGNOcam (intraoral near-infrared transillumination device; KaVo Dental GmbH, Biberach an der Riß, BW, Germany) use near-infrared wavelengths (approximately 780–850

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nm) to produce high-contrast images that reveal subsurface changes caused by demineralization [14]. Several studies have confirmed the clinical utility of NILT in pediatric and mixed-dentition populations. Marinova-Takorova *et al*. [15] demonstrated its high effectiveness for detecting enamel-only occlusal lesions, while De Zutter *et al*. [16] found comparable accuracy between NILT and bitewing radiographs for interproximal caries in children. More recent studies by Patel *et al*. [17], Kanar *et al*. [18], and Marcondes *et al*. [19] have further shown that NILT identifies early, non-cavitated lesions with higher sensitivity than VT, while maintaining excellent patient acceptance. Systematic reviews emphasize that NILT should be considered an adjunctive diagnostic tool rather than a replacement for radiography, particularly for deeper dentinal or secondary lesions [20, 21]. Despite these advances, relatively few studies have directly compared VT and NILT in younger pediatric populations. Most available evidence concerns older children or adults, and consensus is still lacking on the diagnostic value of NILT during early mixed dentition. Moreover, behavioral and dietary factors such as frequent consumption of sugary drinks and refined carbohydrates continue to play a contextual role in caries development and should be considered when interpreting diagnostic findings [22–24]. Therefore, the primary aim of this study was to compare the detection rates of dental carious lesions using visual-tactile examination and near-infrared light transillumination (DIAGNOcam) in children aged 5–9 years. A secondary, exploratory aim was to examine potential associations between dietary habits and caries indices to provide contextual insight into behavioral factors relevant to pediatric oral health. These associations were not intended to infer causation, but rather to guide future longitudinal research.

2. Objectives

The primary objective was to compare the detection rate of dental caries using visual-tactile examination and near-infrared light transillumination (NILT) in children aged 5–9 years.

The secondary, exploratory objective was to assess potential associations between dietary habits and caries indices (dmft/DMFT (decayed, missing, and filled teeth in primary and permanent dentition)), providing contextual interpretation rather than establishing causal relationships.

3. Material and methods

3.1 Characteristics of the respondents

3.1.1 Study population

A total of 185 children (89 girls and 96 boys) aged 5–9 years participated in this study. The participants were divided into five age subgroups (5, 6, 7, 8, and 9 years). The mean age was 7.2 $\pm$ 1.4 years.

3.1.2 Inclusion criteria

- Healthy children aged 5–9 years with primary or mixed dentition.
- No acute dental pain or extensive treatment needs at the time of examination.
- Cooperative behavior sufficient to complete both diagnostic procedures (VT and NILT).
- Written informed consent from parents or guardians and verbal assent from the child.

3.1.3 Exclusion criteria

- Systemic diseases, developmental enamel defects, or craniofacial anomalies.
- Ongoing orthodontic treatment with fixed appliances.
- Use of antibiotics or fluoride supplements within the previous three months.
- Participation in another clinical study within six months prior to recruitment.

3.2 Examiner calibration and reliability

All clinical examinations were carried out by two calibrated examiners (PSt and DLK), assisted by a trained dental hygienist. Calibration was performed on 20 children who were not included in the main sample. Each examiner evaluated the same set of teeth twice using both diagnostic methods (VT and NILT) at a one-week interval. The intra- and inter-examiner reliability were assessed using Cohen's κ statistics, yielding κ = 0.86 (intra-examiner) and κ = 0.82 (inter-examiner), indicating excellent reproducibility. To minimize fatigue and maintain concentration, each diagnostic session was limited to a maximum of 30 minutes per child.

3.3 Study procedure

The study was carried out over a seven-month period, from March 2023 to October 2023, during which all clinical examinations and data collection procedures were completed. Before the examinations, the entire diagnostic process was explained to children and their parents or guardians in age-appropriate language using the tell–show–do technique. Written informed consent and child assent were obtained. Examinations were conducted at the Department of Conservative Dentistry and Endodontics, Pomeranian Medical University in Szczecin, under standardized clinical conditions. Each session was supported by a dental hygienist to ensure patient comfort and accurate data collection. Two diagnostic methods were applied to each participant during a single visit, separated by a 10-minute interval to minimize visual memory bias. The order of examinations was consistent for all subjects: visual-tactile (VT) inspection followed by near-infrared light transillumination (NILT).

3.4 Visual-Tactile (VT) examination

Prior to the VT assessment, all tooth surfaces were cleaned with a rotary brush, rinsed, isolated from saliva, and air-dried for at least 5 seconds using a triple syringe. Examinations were performed under standard dental unit lighting with the patient seated in a dental chair. A plane mouth mirror and a ball-ended World Health Organization (WHO) probe were used to gently explore tooth surfaces in accordance with WHO and International Caries Detection and Assessment System (ICDAS) guidelines. No forceful probing was performed to avoid iatrogenic enamel damage. Each tooth was systemati-

cally examined on the occlusal, mesial, distal, buccal/labial, and lingual/palatal surfaces. Findings were recorded on a standardized dental chart designed for this study.

3.5 Near-Infrared Light Transillumination (NILT) examination

The second diagnostic method employed near-infrared light transillumination using the DIAGNOcam device (KaVo, Germany) (Fig. 1). Examinations were conducted in a dimmed ambient light environment image quality and patient comfort. Tooth surfaces were air-dried immediately before imaging to eliminate light-scattering artifacts caused by saliva.

The DIAGNOcam operates at a near-infrared wavelength of approximately 780–850 nm, which penetrates enamel and dentin to visualize areas of demineralization as darker zones due to light scattering. Real-time images were displayed via the KaVo Integrated Desktop (KiD) software and stored digitally in each patient's electronic record and paper chart. Representative diagnostic images obtained with the device are shown in Figs. 2,3. Each image illustrates the typical visualization of carious lesions: Fig. 2 shows a filling and an adjacent carious lesion located on the mesial surface of a permanent tooth, while Fig. 3 presents a filling on the mesial surface and an occlusal carious lesion in a primary molar. The same set of tooth surfaces examined visually were also assessed using NILT, enabling direct comparison of both diagnostic techniques.

3.6 Calibration, sequence, and safety considerations

All examinations followed a standardized protocol established during the calibration session. The VT examination was always performed first to reflect common clinical workflow and minimize imaging bias. The same operators conducted both methods consecutively; therefore, blinding was not possible and was acknowledged as a study limitation.

All infection control and child safety procedures complied with institutional standards. Sterile, single-use diagnostic instruments and disposable protective covers for DIAGNOcam tips were employed. The diagnostic session for each child lasted no longer than 30 minutes to ensure cooperation and comfort.

4. Results

4.1 Study population

The study included 185 children (48.1% girls, 51.9% boys), divided into five age groups (5–9 years). Caries assessment was performed using two diagnostic methods: visual-tactile (VT) examination and near-infrared light transillumination (NILT). The distribution of the study population by age and sex is presented in Fig. 4. A sample size of 185 participants was considered sufficient to detect a small-to-moderate effect size (Cohen's $d \approx 0.30$) in paired comparisons between diagnostic methods with power ≥ 0.80 and $\alpha = 0.05$. This sample size is also consistent with or larger than comparable pediatric NILT-VT studies reported in the literature.

4.2 Caries indices in primary and permanent teeth

Caries experience in both dentitions was assessed using the DMFT (permanent teeth) and dmft (primary teeth) indices for both diagnostic methods. The distribution parameters are summarized in Table 1.

FIGURE 1. The DIAGNOcam device (KaVo, Germany) prepared for examination with the handpiece and tip attached (photo by authors).

FIGURE 2. Sample diagnostic image showing a filling and an adjacent carious lesion on the mesial surface (photo by authors).

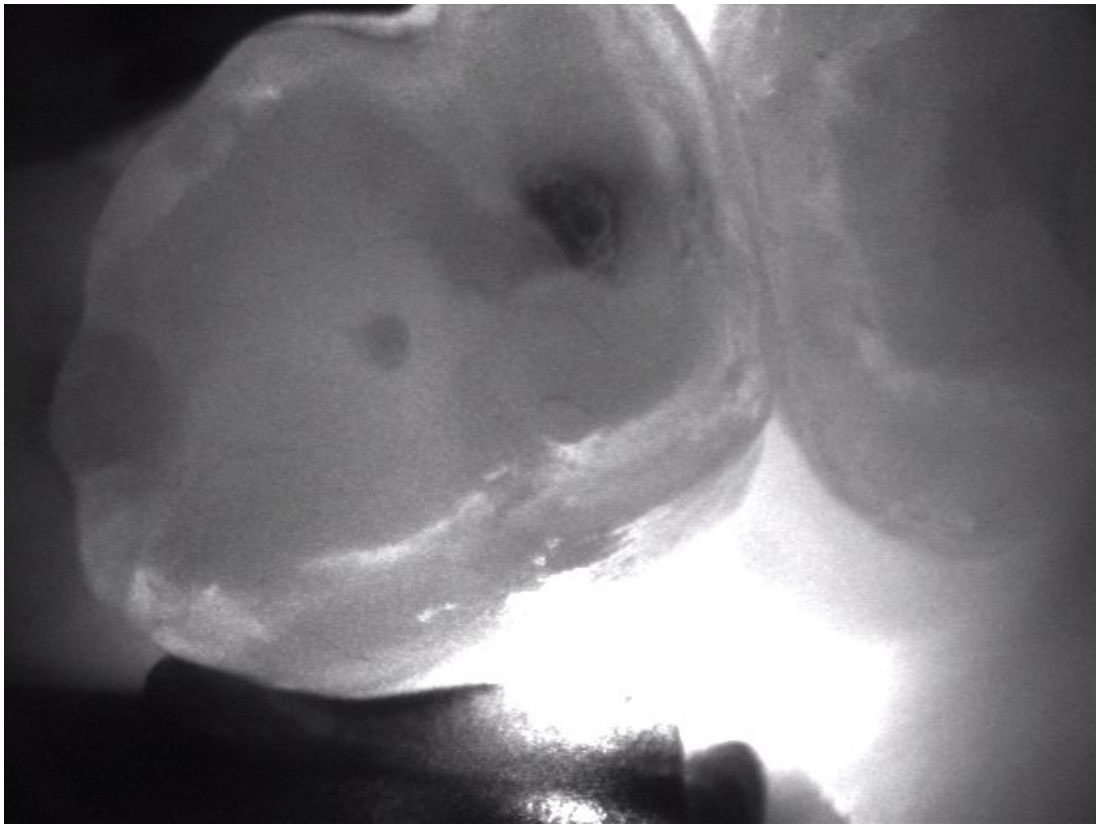

FIGURE 3. Diagnostic image showing a filling on the mesial surface and occlusal caries in a primary molar (photo by authors).

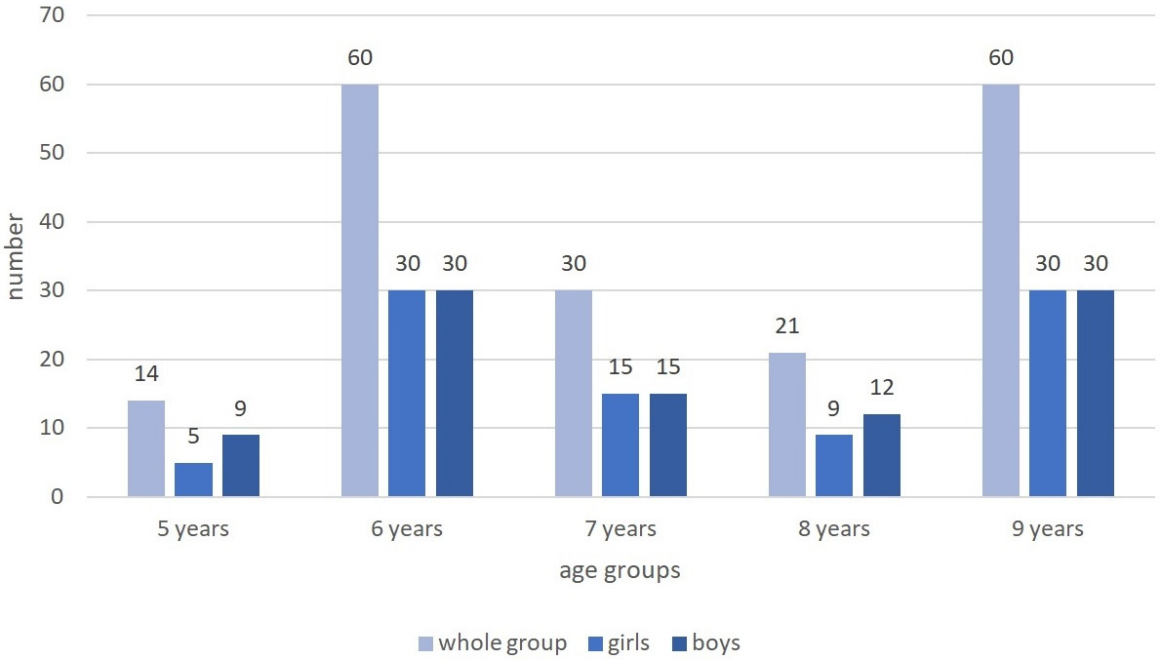

FIGURE 4. Age and sex characteristics of the study group (source: own research).

TABLE 1. Distribution parameters of caries indices (dmft/DMFT) assessed using NILT and VT.

Index	Method	Minimum	Maximum	Mean (SD)	Median	95% CI for Mean	K-S test
DMFT							
	NILT	0.00	4.00	1.38 (1.31)	1.00	1.19–1.57	<0.001
	VT	0.00	4.00	0.79 (1.11)	0.00	0.63–0.95	
dmft							
	NILT	0.00	12.00	4.68 (2.53)	5.00	4.31–5.05	<0.001
	VT	0.00	12.00	4.51 (2.52)	4.00	4.14–4.88	

NILT produced higher mean DMFT and dmft values than VT, indicating a greater detection rate of early, non-cavitated lesions. All variables deviated significantly from normality ($p < 0.001$). NILT, Near-infrared light transillumination; VT, visual-tactile; dmft/DMFT, decayed, missing, and filled teeth in primary and permanent dentition; CI, confidence interval; SD, standard deviation; K-S test, Kolmogorov-Smirnov test.

4.3 Agreement between diagnostic methods

The diagnostic agreement between NILT and VT across all tooth surfaces was moderate to substantial, with Cohen's κ = 0.71 (95% confidence interval (CI) 0.64–0.78). McNemar's test revealed statistically significant differences in detecting early enamel lesions ($\chi^2 = 34.2$, $p < 0.001$), confirming that NILT identified a higher number of early lesions.

4.4 Component analysis of caries indices

The mean values of the decayed (D/d), missing (M/m), and filled (F/f) components for both dentitions are shown in Fig. 5. In permanent dentition, the decayed (D) component was the most prevalent and more frequently identified by NILT. In primary dentition, the filled (f) component predominated and was slightly higher in the VT group.

Table 2 Comparison of caries components and total DMFT/dmft scores between NILT and VT (Wilcoxon signed-rank test).

4.5 Distribution of caries indices

The distribution of DMFT and dmft indices for both diagnostic methods is illustrated in Figs. 6,7. Both indices exhibited positively skewed distributions, indicating that most children presented with few lesions.

4.6 Correlation between caries indices and dietary habits

Spearman's correlation coefficients between dietary variables and caries indices are presented in Table 3. Weak but statistically significant correlations were found between juice consumption and dmft scores across both diagnostic methods ($\rho = 0.195$, $p = 0.008$ for NILT; $\rho = 0.152$, $p = 0.038$ for VT). Although several dietary variables reached statistical significance, all correlation coefficients were weak ($\rho < 0.20$). These findings should therefore be interpreted cautiously given the cross-sectional study design and reliance on self-reported dietary data.

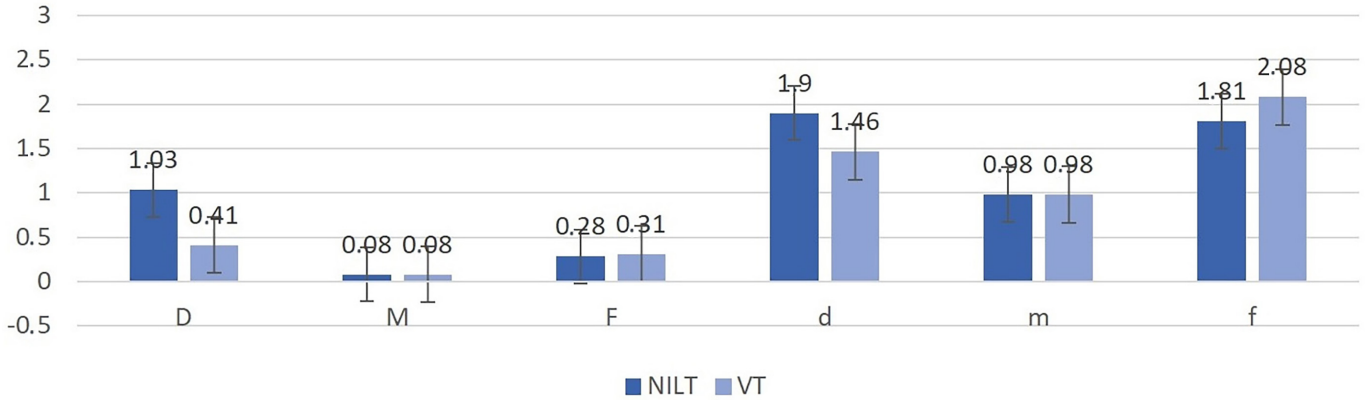

FIGURE 5. Mean scores of individual components (decayed, missing, and filled) of caries indices in permanent and primary teeth assessed by NILT and VT; 95% confidence intervals shown (source: own research). NILT, Near-infrared light transillumination; VT, visual-tactile.

TABLE 2. Comparison of caries components and total DMFT/dmft scores between NILT and VT.

Component	NILT Mean (SD)	VT Mean (SD)	*Z* (Wilcoxon)	*p* Value	Effect Size (*r*)
D	1.03 (1.07)	0.41 (0.70)	−8.469	<0.001	0.62
M	0.08 (0.27)	0.08 (0.27)	0.000	1.000	
F	0.28 (0.66)	0.08 (0.31)	−2.450	0.014	0.18
DMFT total	1.38 (1.31)	0.79 (1.11)	−8.140	<0.001	0.60
d	1.90 (1.44)	1.46 (1.28)	−6.650	<0.001	0.49
m	0.98 (1.15)	0.98 (1.15)	0.000	1.000	-
f	1.81 (1.55)	2.08 (1.78)	−5.530	<0.001	0.41
dmft total	4.68 (2.53)	4.51 (2.52)	−4.490	<0.001	0.33

NILT detected significantly more decayed teeth (D/d) in both dentitions, whereas VT slightly overrepresented filled teeth (F/f). The total DMFT and dmft scores were significantly higher for NILT ($p < 0.001$). NILT, Near-infrared light transillumination; VT, visual-tactile; DMFT/dmft, decayed, missing, and filled teeth in permanent and primary dentition; SD, standard deviation.

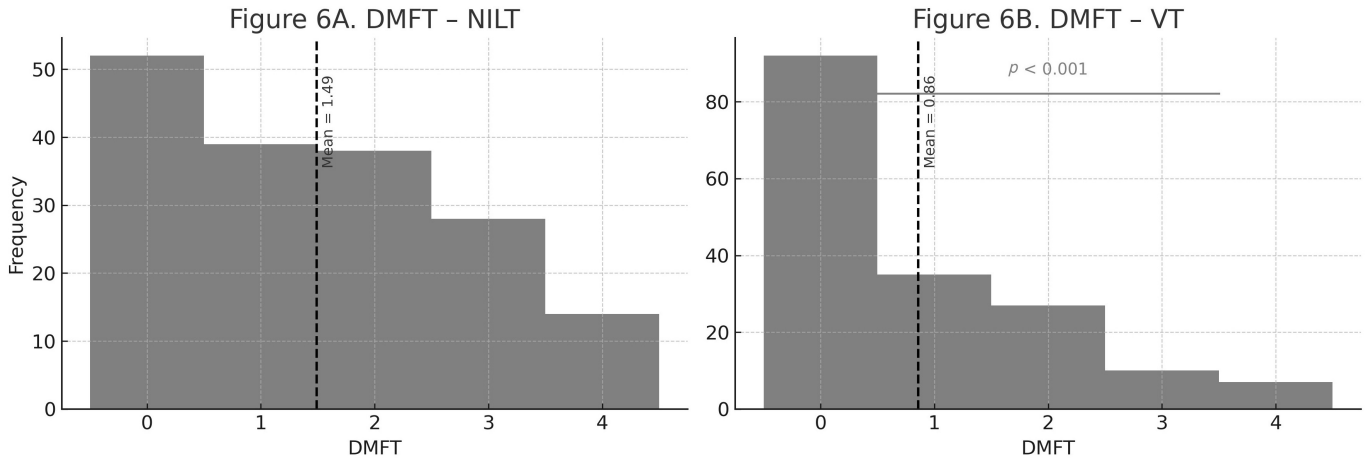

FIGURE 6. Histogram of DMFT values in permanent dentition (VT *vs.* NILT). (A) shows the distribution of DMFT scores obtained using NILT in permanent dentition. (B) shows the distribution of DMFT scores obtained using the VT. NILT detected significantly higher DMFT scores compared with VT ($p < 0.001$, Wilcoxon signed-rank test). DMFT, Decayed, Missing, and Filled Teeth (permanent dentition); NILT, Near-infrared light transillumination; VT, visual-tactile.

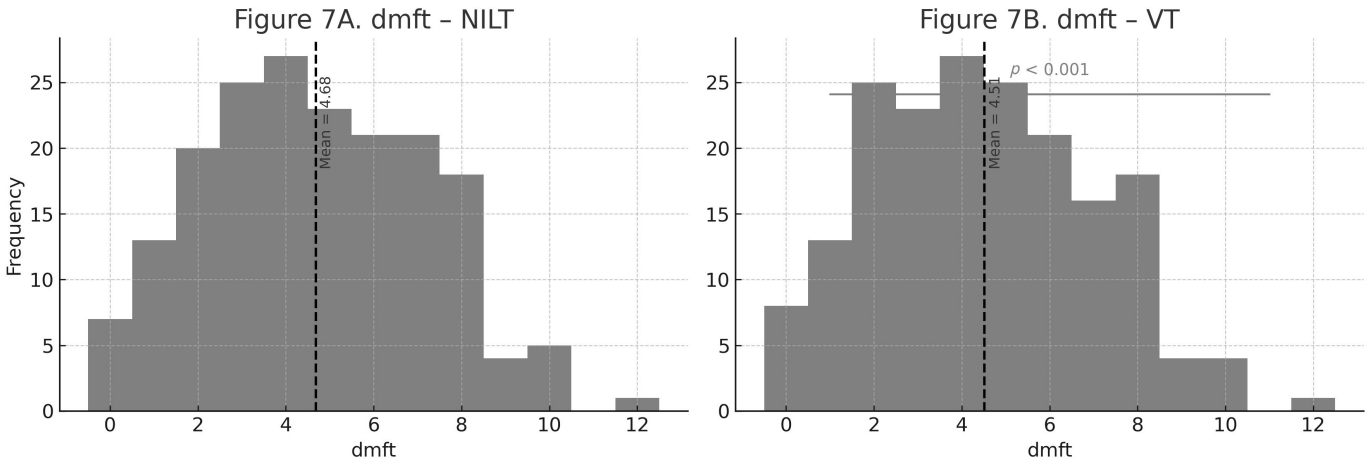

FIGURE 7. Histogram of dmft values in primary dentition (VT *vs.* NILT). (A) shows the distribution of dmft scores obtained using NILT in primary dentition. (B) shows the distribution of dmft scores obtained using the VT. NILT detected significantly higher dmft scores compared with VT ($p < 0.001$, Wilcoxon signed-rank test). dmft, decayed, missing, and filled teeth (primary dentition); NILT, Near-infrared light transillumination; VT, visual-tactile.

TABLE 3. Spearman's correlations between dietary variables and caries indices (VT and NILT).

Dietary Variable	DMFT (NILT)	dmft (NILT)	DMFT (VT)	dmft (VT)
Sugary drinks	−0.120	0.114	−0.091	0.138
Juices	−0.021	0.195 ($p = 0.008$)	−0.042	0.152 ($p = 0.038$)
Sweets	−0.125	0.035	−0.149 ($p = 0.043$)	0.119
Fruits & vegetables	0.138	−0.054	0.152 ($p = 0.048$)	0.148
Fish	0.146 ($p = 0.048$)	0.029	0.134	0.057
Dairy	0.064	0.005	0.067	−0.008
Salty snacks	−0.159 ($p = 0.032$)	−0.014	−0.156 ($p = 0.037$)	−0.043

NILT, Near-infrared light transillumination; VT, visual-tactile; DMFT, Decayed, Missing, and Filled Teeth (permanent dentition); dmft, decayed, missing, and filled teeth (primary dentition).

4.7 Effect of bread type on caries scores

Children who regularly consumed brown bread had higher DMFT scores compared with those who consumed white bread, for both diagnostic methods ($p < 0.001$). No significant differences were found in dmft values. These results are presented in Table 4.

4.8 Effect of school meal source on caries prevalence

Children who consumed home-prepared mid-morning meals showed significantly lower dmft scores compared with those who purchased food at school. This difference reached statistical significance for primary teeth when assessed using the VT method (p = 0.032), whereas no significant difference was observed for the NILT method (p = 0.490). No significant differences were found in permanent dentition (DMFT) for either diagnostic method (Table 5).

4.9 Summary of findings

- NILT detected significantly more early enamel lesions than VT in both dentitions.
- Diagnostic agreement between methods was moderate ($\kappa = 0.71$).
- Weak associations were found between dietary habits and caries indices, supporting the exploratory nature of this analysis.
- Socio-behavioral factors -behavioral factors such as diet and source of school meals have shown limited and method-dependent associations with caries indicators and warrant further multivariate analysis.

5. Discussion

This study compared the detection rates of dental caries in primary and permanent dentition using visual-tactile (VT) examination and near-infrared light transillumination (NILT) in children aged 5–9 years. The findings demonstrated that NILT identified a higher number of early enamel lesions than VT, consistent with previous research emphasizing the enhanced visualization of demineralized enamel under near-infrared illumination [15, 16]. Several studies have shown that NILT can detect non-cavitated and proximal enamel lesions more effectively than conventional VT inspection, particularly when lesions are located interproximally or beneath intact surfaces [25, 26]. This advantage stems from the optical scattering properties of enamel and dentin in the near-infrared spectrum,

TABLE 4. Comparison of DMFT/dmft scores according to bread type (Mann-Whitney U test).

Bread Type	n	DMFT NILT Mean (SD)	DMFT VT Mean (SD)	dmft NILT Mean (SD)	dmft VT Mean (SD)
White	135	1.19 (1.29)	0.67 (1.06)	4.69 (2.62)	4.53 (2.60)
Brown	27	2.19 (1.27)	1.52 (1.25)	4.30 (2.32)	4.19 (2.32)
p-Value	-	<0.001	<0.001	0.550	0.600

NILT, Near-infrared light transillumination; VT, visual-tactile; DMFT/dmft, decayed, missing, and filled teeth in permanent and primary dentition; SD, standard deviation.

TABLE 5. Comparison of caries indices according to school meal source (Mann-Whitney U test).

Meal Source	n	DMFT NILT Mean (SD)	DMFT VT Mean (SD)	dmft NILT Mean (SD)	dmft VT Mean (SD)
Home-made	176	1.39 (1.31)	1.22 (1.30)	4.60 (2.49)	4.43 (2.48)
Purchased	9	1.22 (1.30)	0.67 (1.12)	4.68 (2.53)	6.22 (2.86)
p-Value	-	n.s	n.s	0.490	0.032

NILT, Near-infrared light transillumination; VT, visual-tactile examination; DMFT, Decayed, Missing, and Filled Teeth (permanent dentition); dmft, decayed, missing, and filled teeth (primary dentition); SD, Standard deviation; n.s, Not significant.

which enhance the contrast between sound and demineralized tissue [27]. The higher detection rate observed in our study likely reflects this improved visualization of early-stage lesions rather than overdiagnosis, as similar trends have been reported in studies validated with radiography [17, 25]. However, the absence of radiographic or histological validation remains a limitation. Since all participants were healthy children attending routine dental check-ups, radiographic exposure was avoided in accordance with the ALARA principle. Consequently, the study focused on comparative lesion detection rather than diagnostic sensitivity or specificity. This limitation is shared by other pediatric studies using non-invasive diagnostic devices [28–30]. The present findings reinforce that NILT should be viewed as a complementary, non-invasive adjunct to conventional diagnostic methods rather than a replacement for radiographs, especially in cases where dentinal or secondary caries are suspected [30, 31]. Importantly, the ability of NILT to detect early, non-cavitated enamel lesions aligns well with the philosophy of minimally invasive pediatric dentistry, which emphasizes prevention, early intervention, and tissue preservation [32]. The exploratory analysis of dietary variables revealed several weak but statistically significant associations between juice consumption and dmft scores. These results are in line with earlier evidence linking frequent intake of sugary or acidic beverages to increased caries risk [22–24, 32]. Nonetheless, the cross-sectional design precludes causal inference, and self-reported dietary data may be subject to recall or social desirability bias [33]. Therefore, these findings should be interpreted as contextual observations that support the need for further longitudinal studies with standardized dietary assessments and multivariate analysis to control for confounding variables. Although NILT offers clear diagnostic advantages, several practical considerations may affect its widespread clinical adoption. Device cost, the need for operator training, and limited availability in general or public dental settings remain important barriers [33]. Future research should assess the cost-effectiveness of integrating NILT into routine pediatric dental programs and evaluate its diagnostic performance in broader age groups and different clinical environments. Overall, this study supports the growing body of evidence that NILT enhances the early detection of enamel carious lesions in children without radiation exposure. Its use complements the visual-tactile method and reinforces the principles of preventive, minimally invasive dentistry.

6. Conclusions

The near-infrared light transillumination (NILT) technique demonstrated a higher detection rate of early enamel carious lesions compared with the conventional visual-tactile (VT) examination in children aged 5–9 years.

Due to ethical considerations regarding radiation exposure in healthy pediatric participants, radiographs were not included in the study. Consequently, the analysis focused on comparative lesion detection rather than diagnostic sensitivity or specificity, in accordance with the ALARA principle.

NILT serves as a valuable, radiation-free adjunct that enhances the early detection of non-cavitated enamel lesions but should not replace radiographic assessment when dentinal or secondary caries are suspected.

The exploratory dietary findings provided additional insight into potential associations between eating habits and caries indices; however, given the cross-sectional design and possible confounders, these results should be interpreted with caution.

Future studies should employ longitudinal designs with radiographic or histological validation to establish diagnostic accuracy and cost-effectiveness. Broader implementation research is also warranted to evaluate the feasibility of integrating NILT into community-based pediatric dental programs.

7. Why this paper is important to paediatric dentists?

- Near-infrared transillumination (NILT) is more sensitive than visual-tactile examination in detecting early non-cavitated carious lesions in children.

- Combining NILT with conventional visual-tactile inspection improves diagnostic accuracy and supports minimally invasive paediatric dentistry.
- Real-time visualization using DIAGNOcam enhances patient and caregiver education, promoting preventive behaviours.

ABBREVIATIONS

MID, Minimally Invasive Dentistry; NILT, Near-infrared Light Transillumination; VT, visual-tactile; dmft/DMFT, decayed, missing, and filled teeth in primary and permanent dentition; d/D, decayed teeth; m/M, missing teeth; f/F, filled teeth; WHO, World Health Organization; ALARA, As Low As Reasonably Achievable; ICDAS, International Caries Detection and Assessment System.

AVAILABILITY OF DATA AND MATERIALS

The datasets generated and analyzed during the current study are available from the authors upon reasonable request.

AUTHOR CONTRIBUTIONS

DLK and PSt—created the concepts. PSt—collected the data. EK, RŁ and HG—analyzed the data. PSt, PSk and DLK—led the writing.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Ethical considerations No radiographic examinations were included, as participants were healthy children attending routine dental check-ups. Performing radiographs solely for research purposes would have conflicted with pediatric radiation safety standards and the ALARA principle (As Low As Reasonably Achievable). The study protocol was approved by the Bioethics Committee of the Pomeranian Medical University in Szczecin (Approval No: KB-0012/146/15). Written informed consent was obtained from all parents or legal guardians prior to participation.

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FUNDING

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CONFLICT OF INTEREST

The authors declare that they have no conflict of interest related to this study. The authors declare that they have no financial or personal relationship with KaVo or any other company that could influence this study. The DIAGNOcam device mentioned in the manuscript is standard clinical equipment owned by the university and was not provided or supported by any commercial entity.

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