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REVIEW

Extrinsic stains in primary teeth: insights and interdiction

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Abstract

Unsightly stains are a common concern prompting patients to seek dental care, particularly in primary dentition. The growing demand for aesthetics has driven the rise of toothpaste and devices presenting dubious claims of "sparkly white" teeth. This paper focuses on staining in primary dentition, and its causes, and summarizes evidence-based treatment modalities to combat extrinsic staining. Extrinsic stains are classified according to their origin, etiology, and appearance. Diet, environmental factors, poor oral hygiene, and medication/antiseptics can cause the development of extrinsic stains. Black stains, which are non-scrapable and commonly observed in primary dentition, result from the activity of bacteria like *Prevotella melaninogenica*, *Actinomyces israelii* and *Actinomyces naeslundii*. These bacteria produce hydrogen sulfide, which reacts with iron in saliva to form ferric sulfide, leading to stains resistant to regular toothbrushing. Brown stains are the result of tannins in food or beverages while mouthwashes containing copper salts may stain the teeth green. The primary course of treatment for extrinsic stains is oral prophylaxis, followed by polishing. The use of toothpaste containing oxidizing agents like peroxide has a good outcome in removing external stains. Fungal proteolytic enzymatic compounds incorporated into toothpastes can reduce extrinsic stains. Ingredients such as papain, alumina, and sodium citrate can serve this task. External bleaching is not recommended for primary teeth due to safety concerns. Clinicians must effectively communicate with the caregivers to convey the etiology and strategies for prevention, dietary modification, and the importance of regular oral hygiene measures for minimizing recurrence.

Keywords

Black stains; Dental stains; Dentifrices; Extrinsic stains; Green stains; Microabrasion

1. Introduction

Tooth discoloration or staining is a primary aesthetic concern for patients, motivating them to seek professional care at a dentist. In a survey of young adults, over 90% of responders stated tooth discoloration was the primary cause of dissatisfaction over their dental appearance [1]. Tooth discoloration and dental disorders, including caries, esthetics, tooth loss and dental trauma can affect a child's self-esteem [2]. The present popular entertainment and social media landscape has led to an increased focus on facial aesthetics. This has driven up the demand for "sparkly white teeth" among teenagers and adult consumers. A plethora of products advertise themselves as tooth-whitening agents. However, their results range from unsatisfactory to downright deceptive advertising.

Tooth discoloration is a cause of worry for parents concerned with the aesthetic appearance of their children. Children start to observe a discrepancy in their teeth color by 6 years of age due to a defect [3]. Primary teeth differ from permanent teeth not only in chronology, calcification and size but also in enamel and dentine thickness. The primary enamel structure has decreased levels of calcium and phosphorus, and a higher numerical density of rods [4]. These structural vulnerabilities, coupled with the difficulty of maintaining consistent oral hygiene in children, necessitate a targeted approach to managing tooth stains in primary dentition.

While the majority of existing literature focuses on the aesthetics and management of permanent teeth, the impact of discoloration on primary dentition remains underexplored. This gap underscores the need for research targeting the specific etiologies, mechanisms and treatment strategies for discoloration in primary teeth. This review aims to explain the basis of discoloration or stains and discuss their implications and evidence-based methods of interdiction. Despite its prevalence, managing extrinsic stains in children poses unique challenges due to their age, the difficulty of maintaining oral hygiene and the lack of tailored, evidence-based guidelines for prevention and treatment. By examining these issues, this review seeks to provide a comprehensive understanding of the causes, implications and management of deciduous dentition, equipping clinicians with evidence-based insights to improve outcomes and promote oral health.

2. Basis of tooth color

According to Weerheijm, tooth discoloration refers to any deviation or variation of tooth color from normal [5]. The human eye perceives the color of a tooth based on hue, value and chroma. Hue is the fundamental differentiation between families of colors. Value is defined on a scale of black to white to determine the range of darkness and lightness. Chroma is the saturation of the color [6]. The interplay of light with the tooth's structure significantly impacts perceived color. The effect of refraction and reflection of light on the teeth and their various layers is also *involved* in the variation of tooth color [7]. Thin or transparent enamel allows the underlying dentine to be more visible, resulting in a darker perceived color due to increased light scattering [7–9]. Variations in tooth color are also evident within the same dentition. For example, canines often appear darker than other teeth [10]. Several factors including the source of light, the time of day and the angle of the tooth affect how a tooth color is perceived.

Evaluating tooth color assists in diagnosing stains by providing objective measurements of hue, value and chroma. While visual shade matching is common, it can be subjective [11]. Instrumental methods like colorimetry, spectrophotometry and digital image analysis offer more objective assessments [9]. These techniques can quantify whiteness and yellowness indexes, which are crucial for monitoring dental restorations and whitening treatments. The Chroma Meter, for instance, provides quantitative measurements but has limitations in representing overall tooth color [12]. Enamel thickness affects tooth color, with thicker enamel having a greater impact [13]. This understanding of tooth color and its influencing factors not only aids in diagnosing stains but also enhances treatment planning, ensuring that restorative and aesthetic outcomes align with patient expectations.

3. Classification

Tooth discoloration is classified according to the location of the stains into three types namely: intrinsic, extrinsic and internalized [14–16]. Intrinsic tooth stains are typically pigmented stains that get incorporated over a period into the structural composition of the dental hard tissue. They are a product of various metabolic, traumatic and systemic factors that have oral manifestations. Extrinsic tooth stains are defined as external stains that feature due to the action of external or local agents [17, 18].

Extrinsic stains are classified broadly again into two, namely: direct and indirect stains. Direct stains are a manifestation of compounds incorporated into the acquired pellicle layer on the tooth. Acquired enamel pellicle initiates the bacterial attachment to the tooth surface [19]. The stains present are the effect of the color of the chromogens on the tooth. Indirect staining is a result of chemical interactions on the tooth surface caused by the constant use of cationic antiseptic and metal salts [15, 17]. Eriksen *et al.* [20] classified extrinsic stains according to their origin into metallic and non-metallic stains. Nathoo (1997) proposed a classification for tooth discoloration based on its chemistry into Nathoo (N) classification N1, N2 and N3 [15]. N1 type is described as a colored chromogen that binds to the tooth surface thus resulting in tooth discoloration. N2 types are discoloration that occurs in the color of the chromogenic material that changes after binding to the tooth surface. N3 type is the chemical reaction on the non-colored material bonded on the tooth surface thus presenting as tooth discoloration. An example of the N3 type is the Millard brown reaction [15].

Internalized stains occur when extrinsic agents penetrate the dentin through surface defects, such as cracks. These stains are harder to treat since they reside within the tooth. Treatment options include microabrasion or bleaching agents for lighter cases, while severe cases may require restorative solutions like veneers or crowns to preserve tooth integrity [13].

4. Etiology and mechanism of tooth discoloration

Tooth discoloration, particularly in primary dentition, arises from a diverse array of intrinsic and extrinsic factors, influenced by dietary habits, systemic exposures, environmental interactions and occupational hazards. In children, dietary intake of iron-fortified milk, infant foods and chromogen-rich beverages like tea and coffee often leads to surface discoloration, with tannins and chromogens precipitating to produce brown or black stains [14, 17, 21, 22]. In contrast, adults may experience occupational discoloration, such as black pigmentation in manganese miners or greenish stains in workers exposed to copper and mercury. These occupational stains are further exacerbated by the interaction of environmental factors like trace metals in water, with iron demonstrating a strong correlation with tooth staining. Miners exposed to copper, mercury, lead and nickel have green or bluish-green discoloration on their teeth [17, 23]. Chromic acid fumes can ensure orange stains [23]. There is a correlation between trace elements in water to tooth discolorations. A chief example of this is a positive correlation between the iron element and the staining of teeth [24, 25].

Extrinsic stains in deciduous dentition typically arise from external factors such as dietary residues, bacterial activity or chemical exposure. For instance, the chemical interaction of hydrogen sulfide with iron in dental plaque biofilms can form iron salts, which contribute to discoloration. The chronic use of cationic antiseptics, such as chlorhexidine, can also lead to dark extrinsic stains through interactions with chromogenic compounds on the tooth surface. In addition, over time, the enamel hue in primary teeth may shift due to the accumulation of chromogens and oxidative changes in organic molecules. This review will focus on the mechanisms behind extrinsic discoloration in deciduous dentition, excluding intrinsic factors, which, while relevant to overall dental health, are outside the scope of this discussion.

Stains on the enamel surface of deciduous dentition may change hue over time, with common examples being the yellow to brownish discoloration on the gingival and proximal tooth surfaces with advancing age [26]. The underlying mechanisms often *involve* a combination of physical and chemical processes such as pigments adsorption onto enamel, oxidative changes to organic molecules and penetration of extrinsic agents into microcracks or exposed dentin contribute to the persistence and intensity of stains.

Indirect stains or Nathoo's type 3 stains are a consequence of regular use of cationic antiseptic medications such as chlorhexidine, cetylpyridinium chloride and other mouthwashes [15, 17, 27]. The mechanism of action of chlorhexidine stains is the absorbed cationic ions in antiseptics to bind with the precipitated anionic chromogenic materials present on the tooth surface [17, 28, 29]. Some medications such as minocycline, Amoxycillin, and clavulanic acid, and linezolid can cause extrinsic stains [17, 30].

Dental plaque may also be an agent of enamel staining. Dental plaque refers to the microbial community organized as a biofilm on the tooth surface, embedded in a matrix of polymers of bacterial and host salivary origin [31]. Several attractive forces such as van der Waal's forces, electrostatic, hydration forces, hydrophobic interactions and hydrogen bonds attach these foreign materials to the tooth surface to produce external stains [32]. Understanding these multifaceted etiologies and mechanisms (Fig. 1) is critical for developing effective preventive and therapeutic strategies, ensuring both aesthetic satisfaction and oral health preservation.

5. Types of stains

5.1 Black stain

Black stains (BS) are a special form of dental plaque that present as a thin or wide band of black lines on the labial/buccal and lingual surfaces of teeth that are non-scrapable [33]. It is prevalent in both primary and permanent teeth and is present in both genders [34, 35]. The prevalence of black stains in adults ranges from 4%–20%. A higher prevalence is observed in children [33, 36]. Prevalence in primary teeth with black stains varies from 3%–16% [35]. Black stains can develop as early as 2 years old and most cases present in children older than 4–6 years [32, 37]. It is prevalent equally in both genders, with a predisposition on the lingual surface near the gingiva. Black stains have no affinity to anterior or posterior teeth [33]. The stains are a product of *Prevotella melaninogenica*, *Actinomyces israelii* and *Actinomyces naeslundii* bacteria [38, 39]. Hydrogen sulfide formed by these bacteria reacts with iron present in saliva to form ferric sulfide-producing stains on the tooth. These stains are difficult to remove due to the high content of calcium and inorganic phosphor. Thus, regular toothbrushing is ineffective in removing these stains. Moreover, the recurrence rate is high after stain removal.

Black stains can be a result of iron supplementation or high iodine intake [24]. It is also observed in populations working or living in and around iron foundries and ironworks. Though black stains are prevalent in the primary dentition, salivary maturation as the child grows decreases the presence of black stains [33]. Li *et al*. [34] analyzed the microbiota of black stains in primary children by using 16S rRNA gene sequencing and found that black stains in the primary dentition are correlated with variance in the microbiota in dental plaque rather than in saliva. These patients also appear to have a lower limited microbial diversity which could be the reason for their lower incidence of dental caries [34, 39].

Mesonjesi reported that patients consuming more than 50 g of cheese per day and taking regular milk exhibited black stains [40]. Lactoferrin, a major constituent of milk and cheese is an iron-binding protein. Lactoferrin binds with increased iron in the saliva to produce a black stain [40]. These stains may indicate iron metabolism disorders or anemia [40, 41], though further research is needed to clarify these associations in the context of deciduous dentition. Lactoferrin's iron-binding capacity and resistance to proteolysis contribute to its proposed roles in iron uptake, bacteriostatic action, and immune responses [42]. Recent research suggests lactoferrin as a promising treatment for black stains and other oral pathologies [41, 43]. Additionally, açaí berry, a superfruit with an iron content of 4.5 mg per 100 g of pulp, is commonly consumed by populations in the Amazon region, contributing to black stains on their dentition. Excessive manganese intake from açaí berry may impair iron absorption, further complicating the staining process [44]. This highlights the importance of understanding the interaction of dietary factors and oral health in children.

5.2 Brown stain

Brown stains on deciduous teeth are commonly caused by tannins found in food and beverages, such as tea, coffee and apple juice. It is present as a thin, translucent acquired bacterial-free pellicle. They are prevalent in the buccal maxillary teeth and lingual mandibular teeth [16]. Leung *et al.* [45] found that brown stains were present near the openings of major salivary glands. However, their correlation is limited [45]. The limited correlation may stem from variations in pellicle thickness across the dental arches and the challenges associated with analyzing its structure and composition due to insufficient sample quantities [19, 46]. An interesting brown stain phenomenon is observed among professional swimmers [47]. These stains are hard, brown tartar deposits consisting of proteins and peptides present on acquired enamel pellicles on the anterior teeth [16, 47]. This occupational stain is caused by the antimicrobials present in swimming pool water. The pool has a higher pH than saliva, resulting in the breakdown of salivary proteins that deposit on the tooth [47–49]. Elevated levels of lactoferrin in saliva may further contribute to staining, as lactoferrin, in combination with iron and tannic acid, can produce stains on enamel [50]. This highlights the need to understand the role of diet and environmental factors in the formation of extrinsic stains on deciduous teeth.

5.3 Orange stain

Serratia marcescens and *Flavobacterium lutescens* can cause orange stains on teeth [16]. Prolonged exposure to chromic acid can also result in orange stains [17]. These stains are rarer than black, green or brown stains. They are seen on the gingival third and facial surfaces of anterior teeth [51].

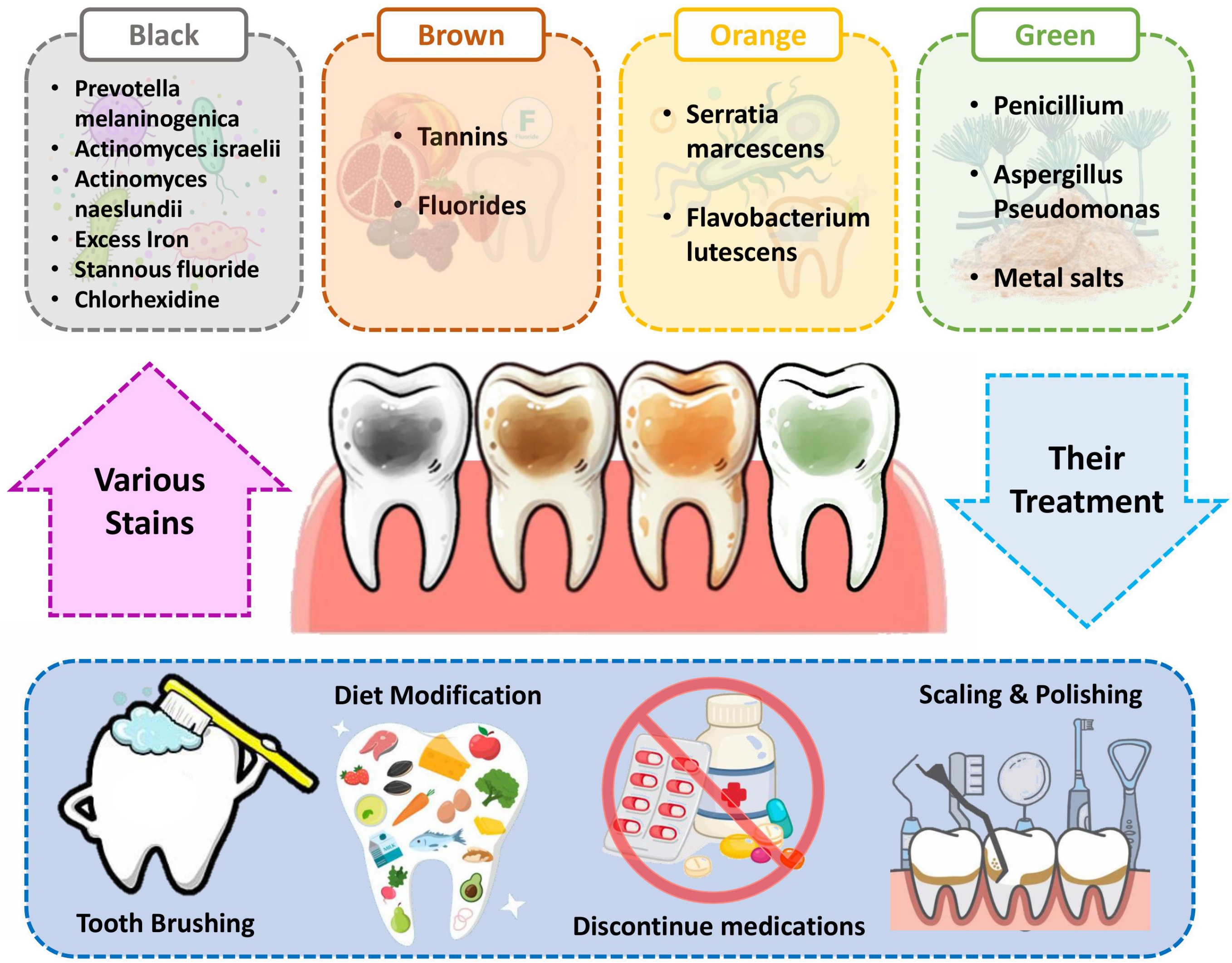

FIGURE 1. Causes of various stains and their treatment.

5.4 Green Stain

Green extrinsic stains can occur in primary teeth as an accumulation of thick bands of chromogenic bacteria. They are most often visible in the cervical third and incisal edge of the maxillary and mandibular anterior teeth. Leung *et al.* [45] reported that green stains are present on the labial surface of anterior teeth and males have a slightly higher predilection. Green chromogenic stains are the product of fungi such as *Penicillium*, *Aspergillus* species and *fluorescent bacteria*. As light is a prerequisite for their growth, anterior teeth are most affected [45].

Green stains manifest as occupational exposure to metal salts or due to regular consumption of drugs with metal salt constituents. Orthodontic appliances can release metal ions into the saliva. Silver and lead dust exposure can result in bluish-green discoloration. Copper and nickel salts are observed to cause green stains [17]. Mouthwashes contain copper salts that can stain the teeth green. Children and adults who are exposed to brass fumes for a long duration can show green tooth stains. Prolonged antibiotic usage is associated with chromogenic microbial accumulation. *Pseudomonas* species cause green tooth discoloration following the release of pyocyanin pigment. Mouth breathing is also to be a contributing factor [14].

5.5 Stannous fluoride stain

Stannous fluoride is a topical fluoride commonly used for caries-preventative activity. When applied at concentrations of 2%–4%, it reduces dental caries by 37%. However, increased concentrations of up to 8% stannous fluoride manifested dark brown and black pigmentation, primarily on caries-affected areas of the tooth surface in both permanent and deciduous dentition [52]. The mechanism of staining likely *involves* the formation of stannic sulfide (SnS_2) on tooth surfaces, resulting from reactions between stannous ions and sulfhydryl groups in denatured pellicle proteins [53]. The staining potential varies among SnF_2 (Stannous fluoride) formulations, depending on the availability of stannous ions [54]. This emphasizes the importance of considering the risk of extrinsic staining when using stannous fluoride, particularly in children's teeth.

5.6 Silver diamine fluoride stain

Silver diamine fluoride (SDF) is commonly used in pediatric dentistry to arrest the progression of dental caries in deciduous dentition [55]. Silver diamine fluoride mechanism of action *involves* antibacterial effects, inhibition of demineralization, promotion of remineralization and protection of dentin collagen [56, 57]. The discoloration is primarily due to the formation of silver chloride and silver-doped hydroxyapatite on the tooth surface, leading to an extrinsic stain that can affect the aesthetic appearance of carious teeth [57, 58]. It consists of silver and fluoride combined with ammonia [37]. However, it has a side effect of staining the carious tooth in the process. Recent research has shown that potassium iodide application after the application of silver diamine fluoride can reduce the staining side effect [59, 60]. The aesthetic perception of black staining associated with SDF is not directly related to its acceptability and satisfaction of patients and parents; it is related to reduced acceptance among dental professionals [61].

5.7 Metallic stain

Extrinsic metallic stains of teeth are predominantly associated with occupational exposure to metallic salts. Several drugs contain metal salts such as iron and copper. Potassium permanganate produces a deep violet-black color when used regularly as mouth rinses. Silver nitrate salts cause a grey color [8, 23].

Several theories have been put forward to explain the mechanism of chlorhexidine staining teeth. Berk proposed a non-enzymatic browning reaction whereby a protein and carbohydrate in the acquired pellicle react to chlorhexidine. When used regularly, chlorhexidine can accelerate the formation of the acquired pellicle [62, 63].

Warner *et al.* [64] suggested pigmented sulfide formation of iron with chlorhexidine. Another theory claimed that chlorhexidine precipitated dietary chromogens [65]. Chlorhexidine may produce stains reacting with food dye [66]. However, this hypothesis remains unlikely as there is a negative correlation between chromogenic stains and beverage consumption [28].

6. Prevention

American Academy of Pediatrics guidelines recommend that parents brush their children's teeth as soon as they erupt. Brushing twice daily; in the morning and evening. Dental floss may be used in between the teeth when they come in contact with each other [67].

Research has long shown a correlation between iron and extrinsic black stains. Hence, a child with black extrinsic stains must be assessed for excess iron intake and dietary patterns [22]. Along with the source and quantity of iron consumed, the inhibitors and enhancers of iron absorption lead to the ultimate amount of iron absorption [22]. Narrowing down the sources of iron and diet modification can stop the recurrence of extrinsic stains. Fluoride treatment is a highly recommended preventive measure among professional swimmers [47, 68]. Diet modification followed by inhibitory action against the metal salts in industrial exposure can prevent the occurrence of extrinsic stains. Maintaining good oral hygiene with monitored usage of cationic antiseptics or mouthwashes will enhance stain-free oral cavities.

7. Diagnosis and interdiction

A scratch test helps identify extrinsic stains. Stained teeth are scratched gently with a sharp dental instrument to evaluate their surface texture. Extrinsic stains are removed rather quickly by light scratching. Scratch-resistant stains are regarded as tenacious [17]. A standardized classification defining the diagnosis of dental stains is not well established. Several authors have proposed various classifications. Koch *et al.* [69] contemplated the appearance of dark dots with a diameter of less than 0.5 mm and forming linear discoloration that is parallel to the gingival margin of at least two different teeth with no cavitation on the enamel surface. Shourie examined the presence and absence of pigmented plaque into no line; incomplete coalescence of pigmented dots and a continuous line formed by pigmented spots [69]. Leung *et al.* [45] evaluated dental stains and scored them into four groups as shown in Table 1 (Ref. [45]), whereas Gasparetto *et al.* [70] presented an additional criterion depending on the area of the tooth surface that is affected: 1st degree: pigmented dots/thin lines with incomplete coalescence parallel to the gingival margin; 2nd degree: continuous pigmented lines, which are easily observed and limited to half of the cervical third of the tooth surface; 3rd degree: pigmented stains that surpass half of the cervical third of the tooth surface. Similar to Gasparetto, the Lobene stain index as depicted in Table 2 (Ref. [71, 72]), evaluated extrinsic stains by visual inspection of the tooth [71, 72].

The primary course of treatment recommended in tooth-discolored patients is oral prophylaxis and polishing with abrasives such as prophylactic paste [16]. Often a combination of scaling and polishing along with surface-active agents such as toothpaste is recommended regularly [15, 26, 73, 74]. However, the type of stain is the sole determinant in its course of removal.

Toothpaste containing oxidizing agents such as peroxide can help to remove external stains [75]. An *in-vitro* screening assay for tooth stains and comparisons with different oral hygiene products conducted by Wang *et al.* [76] found that specialized whitening toothpaste removed dental stains better than non-whitening toothpaste. Sodium triphosphate (STP), a sodium salt of triphosphoric acid, having surfactant and chelating properties is used in oral hygiene products to help in dental stain removal [71]. Calcium carbonate and perlite abrasives are effective in extrinsic stain removal and constitute a potent fluoride source [71].

As extrinsic stains are primarily incorporated in the pellicle, protease-like enzymes could degrade the stains and potentiate their removal [77]. Research has shown natural and synthetic enzyme-derived mixtures to be effective. A fungal proteolytic enzymatic mixture incorporated into toothpastes was effective in reducing extrinsic stains. Similarly, papain, papain with bromelain, alumina and sodium citrate have been effective in removing stains from the tooth surface [78–80]. Whitening agent toothpaste can take up to 2–6 weeks on average and up to a maximum of 12 weeks to show effectiveness [71]. However, a major drawback with these solutions is the lack of supporting evidence regarded their long-term and recurrent effects [71].

External dental bleaching can be implemented in cases of

TABLE 1. Leung classification on diagnosing dental stains [45].

Score for the degree of staining	Amount of the surface area *involved*
Score 1	Staining of a thin line measuring 1 mm or less in width across the surface
Score 2	Staining of one-third of tooth surface
Score 3	Staining of two-thirds of tooth surface
Score 4	Staining *involving* all dental surface

TABLE 2. Lobene stain index [71, 72].

Color/Stain Intensity	Area Stained
No stain	No stain detected
Light stain	Staining of one-third of tooth surface
Moderate stain	Staining *involving* 1/3 to 2/3 tooth surface
Heavy stain	Staining of more than 2/3 of tooth surface

severe external dental stains [81]. Tooth bleaching uses oxidizing agents such as hydrogen peroxide 1%–10% or carbamide peroxide 20%–22%. These agents have antimicrobial effects. However, they can have severe effects on oral health. Indirect, metallic, or Nathoo's type 3 classification is comparatively difficult to remove. In such cases, an additional agent such as carbamide peroxide can be used [15, 82]. These agents do not alter the oral microbiota but can reduce the recurrence of black stains in the anterior teeth [81]. At-home bleaching agents are popular due to their ease of use, low cost and effectiveness. Nevertheless, the American Academy of Pediatric Dentistry strongly discourages the use of full-arch cosmetic tray bleaching in primary teeth [83]. Microabrasion can serve to remove dental stains by abrading a thin layer of enamel. The procedure consists of the application of a low-concentration acid such as hydrochloric and phosphoric acids with abrasives followed by polishing [84, 85]. Tooth discoloration in children, particularly in deciduous dentition, can be caused by extrinsic or intrinsic factors, affecting both aesthetics and psychosocial well-being [37, 86]. Treatment options vary depending on the etiology, severity, and patient age. Tooth whitening in young children requires careful consideration due to potential adverse effects such as tooth sensitivity and gingival irritation [87]. As described previously, minimally invasive techniques like microabrasion can be effective for treating enamel defects in young patients. For more severe cases, composite resins or novel techniques like resin infiltration may be considered [88]. It's crucial for dental practitioners to understand the etiology of discoloration to provide appropriate treatment [14]. Treatment decisions should balance risks and benefits, considering the patient's oral health, age, and desired outcome [87, 89].

Schoenly *et al.* [90] studied selective ablation of extrinsic dental enamel stains using a 400-nm laser to remove dental stains with reduced damage to the enamel and concluded that was efficient above 3 J/cm^2 with nominal damage to the underlying enamel. Albelda-Bernardo *et al.* [91] investigated phototherapy application on black stains and reported positive results were upheld. There was a considerable reduction in the color, area, and bacterial colonization of black stains with minimal disruption of enamel on the tooth [91, 92].

Koleoso *et al.* [93] studied extrinsic tooth stains in a Nigerian population and found that most often parents or children are unaware of the chromogens present in plaque and deposits on teeth. A relatively easy measure is to improve oral hygiene practices [94]. Regulation of the excess amount of iron ingestion in multiple forms should also be considered. Various sources of metal salt intake should also be thoroughly assessed to inhibit stain growth. The dentist should be cognizant of the color changes associated with fluorides such as stannous fluoride and silver diamine fluoride and weigh the necessity of their use due to their ability to stain teeth.

Over-the-counter (OTC) tooth whitening products, containing hydrogen peroxide or carbamide peroxide, have gained popularity due to increased demand for esthetic dental care [95]. While these products generally safe, they can cause temporary tooth sensitivity and potential enamel damage. Hydrogen peroxide, when used in high concentrations or for prolonged periods, may harm oral tissues [96, 97]. However, low concentrations (3% or less) have shown no adverse effects in long-term studies [98]. Abrasives in dentifrices, measured by relative dentin abrasivity (RDA), play a role in stain removal but may contribute to tooth wear [99]. Most OTC whitening products, except for strips, are effective only in removing extrinsic stains [100]. Dental professionals should consider individual patient needs and product composition when recommending OTC whitening products [95].

Clinical practice guidelines for managing tooth staining and caries in children emphasize early detection, risk assessment and preventive measures [101–103]. For deep carious lesions in primary teeth, indirect pulp capping, pulpotomy and silver diamine fluoride are effective treatments [103]. Molar-incisor hypomineralization requires tailored interventions based on severity and patient age [102]. Parents play a crucial role in children's oral health through supervised toothbrushing, which should begin with the eruption of the first tooth and continue until at least age 7 [104]. However, parents face barriers such as managing children's behavior and environmental stressors [104]. Oral health promotion materials for parents should address these barriers and provide consistent messages aligned with current guidelines [105].

8. Clinical significance

Following the principle of *primum non nocere*, a clinician must choose the least invasive approach for treating stains after first eliciting a thorough case history including details of diet and medications. It would be wise to defer treatments such as microabrasion and laser ablation until other treatments have failed to provide a satisfactory outcome. Clear and reassuring communication with the patient, parent or caregiver is essential. Talebi *et al.* [106] claimed that merely informing the caregivers does not improve the condition of their ward unless they are reminded in a practical and relatable manner. Details regarding techniques for the prevention and removal of causative factors should be communicated clearly to the parent. A frank appraisal of the pros and cons of the various treatment modalities should be presented to the parent before opting for the best non-invasive approach initially. Treatment planning should critically weigh the risk-benefit ratio for the patient [92].

9. Conclusions

The presence of extrinsic stains in primary teeth remains a prevalent concern, impacting both aesthetics and the psychosocial well-being of children and their families. This review highlights the multifactorial nature of these stains, encompassing dietary habits, oral hygiene practices and environmental factors. Interdiction strategies, ranging from preventive measures to professional interventions, emphasize the pivotal role of early education and routine dental care in mitigating this issue. Extrinsic stains are often caused by external agents such as chromogenic bacteria, certain fluorides, diet, and prolonged medication use. These stains can be mitigated by eliminating or addressing the causative factors, such as modifying the diet or medication. At-home treatments for stains *involve* the use of chemically active whitening dentifrices. Professional treatment consists of microabrasion, laser ablation and polishing. Clear communication with the patient's parents and caregivers is crucial. A clinician must explain the etiology of the stain and emphasize the significance of regular oral hygiene measures as the cornerstone of combating extrinsic stains in the pediatric population. However, the long-term effectiveness of these treatments, especially in younger children with developing dentition, still requires more robust, large-scale studies. Many existing studies are limited by small sample sizes and varying follow-up periods. Furthermore, the potential risks associated with certain treatment modalities, particularly in children with sensitive or incomplete enamel, require further investigation. Future research should aim to refine diagnostic criteria, explore innovative treatment modalities and establish evidence-based guidelines to enhance outcomes. Addressing extrinsic stains in primary teeth not only improves oral health but also instills positive lifelong dental habits, underscoring its significance in pediatric dentistry.

AVAILABILITY OF DATA AND MATERIALS

Not applicable.

AUTHOR CONTRIBUTIONS

SB, NP and HP—conceptualization. HP and FWL—software. SP, AR and MC—validation. MMM and GM—formal analysis. SP, MMM and FWL—resources. AR and MMM—data curation. SB, NP, HP, FWL and SP—writing–original draft preparation. AR, MC, MMM and GM—writing–review and editing. FWL and SP—visualization. NP, HP and GM—supervision. All authors have read and agreed to the published version of the manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

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