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In Vitro Evaluation of pH Levels in Pediatric Medications and Their Potential Risk to Dental Health

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Abstract: ***This study investigated the pH levels of five commonly used pediatric medications—immune syrups, homeopathic remedies, and an ibuprofen suspension—through an in vitro approach to assess their potential effects on dental health. A total of 200 samples were analyzed using a calibrated pH meter, revealing that four out of five products had pH values below the critical threshold of 5.5 for enamel demineralization. The results showed a statistically significant difference across medication types, with Schuessler's Salts maintaining a near-neutral pH, while ImmunoMix Advanced exhibited the lowest pH value. These findings suggest that frequent or prolonged use of these medications could contribute to enamel erosion and dental caries in children. Increased awareness among healthcare providers and caregivers is essential to mitigate these risks through informed medication choices and preventive oral hygiene practices.***

Keywords: pH levels, pediatric medications, enamel erosion, immune syrups, homeopathic remedies

1. Introduction

Children in early childhood often experience frequent illnesses due to their developing immune systems, leading to the common use of remedies such as nonsteroidal anti-inflammatory drugs (NSAIDs), homeopathic preparations, and various syrups aimed at boosting immunity. Although these treatments aim to promote health, liquid pediatric medications may unintentionally compromise dental integrity.

The combination of high sugar content and low pH in medications such as NSAIDs and some homeopathic remedies can contribute to dental caries and enamel erosion, especially with frequent or prolonged use.

The American Academy of Pediatrics highlights that frequent exposure to added sugars, including those in medications, is a critical risk factor for dental caries, particularly when these sugars remain in contact with teeth for extended periods or are consumed frequently throughout the day (1). Studies have shown that many pediatric liquid medications contain up to 4 grams of sugar per dose, and chronic use increases caries risk (2, 3, 4).

Acidic pH and high titratable acidity in medications further contribute to enamel erosion, especially in deciduous teeth, as demonstrated in in vitro studies (5, 6). Both sugar-containing and sugar-free formulations can be erosive if their pH is below 5.5, but sugar-containing medicines pose a dual risk due to both cariogenic and erosive potential (6).

Homeopathic remedies are not supported by high-quality evidence for efficacy in increasing immunity or treating illness in children, and their safety profile is uncertain (7, 8, 9). While most homeopathic products are highly diluted and may not contain significant sugar or acid, some commercial preparations (e.g., teething tablets, syrups) may include excipients that are cariogenic or erosive (7). Homeopathic remedies, similar to conventional pediatric medications, also contain sugars and acids. Their administration follows specific rules – they are taken several times a day, usually between meals, kept under the tongue for prolonged periods, and should not be combined with fluoride-containing toothpastes. In many cases, one of the doses is given in the evening before bedtime. These factors, together with the presence of sugars and acids, increase the risk of developing carious lesions associated with the frequent use of homeopathic remedies (10). This highlights the need for careful consideration of the dental implications of pediatric medications and homeopathic treatments. This study addresses a notable gap in awareness regarding the acidic potential of pediatric liquid medications and their implications for dental health, emphasizing the need for preventive strategies in pediatric care.

Aim: The aim of this study is to compare the pH levels of commonly used pediatric medications, including immune syrups, homeopathic remedies, and NSAIDs, to assess their potential impact on dental health.

2. Materials and Methods

This in vitro laboratory study was designed to evaluate and compare the pH levels of commonly used pediatric medications to assess their potential impact on oral health. Five medication groups were selected for analysis: immune syrups (Biozin Kids and ImmunoMix advanced), two homeopathic remedies (Schuessler's Salts and Camilia Dento Baby), and ibuprofen suspension (Nurofen Kids).

A total of 200 samples were prepared, with 40 samples per medication group. Liquid formulations (Biozin Kids, Nurofen Kids, Camilia Dento Baby and ImmunoMix advanced) were directly measured by dispensing 10 mL of each solution into sterile glass containers. For tablet formulations (Schuessler's Salts), tablets were pre-dissolved in deionized water at a 1:1 mass-to-volume ratio (1 g tablet per 1 mL water) to ensure consistent dissolution. All samples were prepared under standardized laboratory conditions to minimize variability.

pH and Temperature Measurement: A high-precision pH meter with an accuracy of ±0.01, equipped with an integrated thermometer (pHTestr 50S Spear-Tip Waterproof Pocket

Tester, Premium 50 Series, Oakton, USA), was used for pH and temperature measurements. The pH meter was calibrated prior to each measurement session using standard buffer solutions (pH 4.0, 7.0, and 10.0) to ensure accuracy.

For each sample, 10 mL of the prepared solution was placed in a sterile glass beaker. The pH meter electrode was submerged for one minute while the sample was gently stirred using the electrode tip to ensure homogeneity. To prevent cross-contamination, the electrode was thoroughly rinsed with distilled water and dried with sterile gauze between measurements. Three consecutive pH readings were taken at one-minute intervals for each sample, and the mean pH value was recorded as the final result. The temperature of each sample was simultaneously recorded during pH measurements.

The mean pH, mean temperature, and standard deviation were calculated for each medication group based on the 40 samples per group. Data were processed using Microsoft Excel 2019 for initial calculations, followed by statistical analysis with SPSS v.26.0 (SPSS Inc., Chicago, IL, USA). Descriptive statistics were used to summarize the pH and temperature data, and one-way analysis of variance (ANOVA) was employed to compare pH values across the four medication groups, with a significance level set at $\alpha = 0.05$.

3. Results

The pH levels of the five pediatric medications are presented in Table 1.

Table 1: Comparative analysis of the intrinsic acidity of the studied products

pH / Product	Mean ± SD	Min	Max	t-test
Schussles's salts (1)	6.71 ± 0.23	6.39	7.41	$p_{1,2} = 0{,}000$, $p_{1,3} = 0{,}000$
Nurofen (2)	4.22 ± 0.26	3.31	4.98	$p_{1,4} = 0{,}000$, $p_{1,4} = 0{,}000$
Biozin Kids (3)	4.48 ± 0.41	3.95	5.53	$p_{1,5} = 0{,}000$, $p_{2,3} = 0{,}003$
Camilia Dento Baby (4)	5.29 ± 0.35	4.81	6.37	$p_{2,4} = 0{,}000$, $p_{2,5} = 0{,}000$
ImmunoMix (5)	3.74 ± 0.32	3.16	4.41	$p_{3,4} = 0{,}000$, $p_{3,5} = 0{,}000$ $p_{4,5} = 0{,}000$

Schuessler's Salts exhibited a near-neutral pH (6.71 ± 0.23), while Camilia Dento Baby (5.29 ± 0.35), Biozin Kids (4.48 ± 0.41), Nurofen Kids (4.22 ± 0.26), and ImmunoMix Advanced (3.74 ± 0.32) had acidic pH values below the critical threshold of 5.5 for enamel demineralization. Statistical analysis revealed significant differences between Schuessler's Salts and all other groups ($p<0.001$), as well as between other pairs (e.g., $p=0.003$ for Biozin Kids vs. Nurofen Kids, $p<0.001$ for ImmunoMix Advanced vs. Camilia Dento Baby).

4. Discussion

The results of this study reveal significant variations in the pH levels of commonly used pediatric medications, with implications for dental health in early childhood. Schuessler's Salts, with a near-neutral mean pH of 6.71 ± 0.23, pose minimal risk to enamel, as their pH is above the critical threshold of 5.5 for demineralization (6). In contrast, Nurofen Kids (4.22 ± 0.26), Biozin Kids (4.48 ± 0.41), Camilia Dento Baby (5.29 ± 0.35), and ImmunoMix Advanced (3.74 ± 0.32) exhibited acidic pH values, consistent with prior studies reporting that many of the pediatric medications have pH below 5.5. These acidic formulations, particularly ImmunoMix Advanced with the lowest pH, may pose a considerable risk for enamel erosion and caries, especially with frequent or prolonged exposure.

The most frequently used homeopathic remedies and medications by children to "support immunity" or for symptom relief are Camilia (for teething), Arnica (for bruising), and complex remedies for upper respiratory tract infections such as Schussler's salts. These are commonly used for self-limiting conditions like colds, teething, and minor injuries, as documented in large cohort studies and surveys of homeopathic use in children (11, 12). These products, often administered as liquids or tablets, may contain sugars and acidic excipients, posing a risk for dental caries and erosion with repeated use (13).

Despite their popularity, high-quality systematic reviews and meta-analyses consistently show no convincing evidence for efficacy in preventing or treating infections or boosting immunity in children (14). Furthermore, some homeopathic products, especially syrups and teething tablets, have been associated with dental risks due to their sugar content and acidity (13).

The intrinsic pH value of the homeopathic remedy Camilia is not explicitly stated in public sources. Camilia is a homeopathic medicine designed for teething relief in babies, containing active ingredients such as Chamomilla 9C HPUS, Phytolacca decandra 5C HPUS, and Rheum 5C HPUS, with purified water as the non-medicinal ingredient. It is described as a sterile, water-based solution free of preservatives, dyes, and other additives. Since Camilia is primarily composed of purified water with highly diluted homeopathic ingredients, its pH is likely close to that of purified water, which is typically around 7.0 (neutral) at 25°C. However, the observed mean pH of 5.29 ± 0.35 suggests the presence of acidic excipients, contradicting assumptions of neutrality and indicating a potential erosive risk. This finding is particularly concerning given Camilia's administration protocol, which involves multiple daily doses, increasing contact time with teeth and elevating caries risk (10).

Studies evaluating the pH of pediatric liquid medications, including analgesic suspensions such as Nurofen for Children, consistently report that most formulations are acidic, with pH values frequently below the critical pH for dental demineralization (5.5). In a comprehensive analysis of 71 pediatric medicines, including commonly prescribed analgesic suspensions, pH values ranged from 2.3 to 10.6, with 42.25% of products below the critical pH and 25.35%

below pH 4.5 (15). Syrup formulations and those dosed multiple times per day, such as ibuprofen suspensions, tended to have the lowest pH and highest cariogenic and erosive potential, primarily due to the inclusion of flavoring agents and stabilizers (15). The acidic nature of Nurofen Kids aligns with previous findings that ibuprofen suspensions often have pH values below 4.5 due to excipients like maltitol and flavoring agents (15, 16).

Further, a study of 97 pediatric medicines found that 57% of formulations had an endogenous pH below 5.5, with both sugar-containing and sugar-free ibuprofen suspensions frequently falling into the acidic range. The erosive potential was not solely determined by sugar content but also by the dose form and excipients, such as maltitol and flavorings, which are present in Nurofen for Children (16). These findings are consistent with reports from India and similar settings, where the pH of pediatric oral suspensions typically ranges from 3.6 to 7.3, and analgesic suspensions are predominantly acidic (15).

The acidic nature of these suspensions is clinically relevant, as repeated exposure to medications with pH below 5.5 can contribute to dental demineralization and increase the risk of early childhood caries, especially in children receiving long-term or frequent dosing (15, 16).

Immune support syrups such as Biozin Kids and Immunomix Advanced are marketed for pediatric immune health and typically contain combinations of vitamins (e.g., vitamin C, vitamin D), minerals (e.g., zinc), herbal extracts (e.g., elderberry, echinacea, propolis), and sometimes probiotics or β-glucans. These ingredients are selected for their purported immunomodulatory properties, including enhancement of innate and adaptive immune responses, anti-inflammatory effects, and support for mucosal immunity (17, 18). The significant difference ($p<0.001$) between these syrups and Schuessler's Salts underscores the variability in formulation and its impact on dental health. In vitro studies confirm that repeated exposure of primary enamel to acidic pediatric medicines, even those that are sugar-free, results in significant demineralization and surface hardness loss, especially in the presence of dental biofilm (19, 20). The erosive potential is determined more by the formulation's pH and titratable acidity than by sugar content alone (15, 16). Therefore, regular use of acidic pediatric liquid medications—including immune support syrups and ibuprofen suspensions—can contribute to dental demineralization and increase caries risk in children, particularly with frequent or prolonged dosing (15, 17, 18).

The frequent use of these acidic medications, especially in children with developing dentition, amplifies the risk of early childhood caries and enamel erosion, as repeated exposure to pH below 5.5 can lead to significant demineralization (5, 6, 19). The administration patterns of homeopathic remedies, such as prolonged oral retention and bedtime dosing, compound these risks by limiting salivary clearance (10). These findings highlight the need for pediatricians and parents to be aware of the dental implications of commonly used medications. The lack of high-quality evidence supporting the efficacy of homeopathic remedies like Schuessler's Salts and Camilia for immunity or teething relief further questions their routine use, especially given their potential dental risks (7-9, 14).

5. Limitations

The study's findings are limited by the lack of in vivo data on long-term dental outcomes and the potential variability in pH measurements due to differences in formulation batches or storage conditions. Additionally, the clinical significance of short-term exposure to acidic medications remains underexplored.

6. Conclusion

This study confirms that most commonly used pediatric medications, particularly immune syrups and ibuprofen suspensions, exhibit acidic pH values below the critical demineralization threshold of 5.5. Schuessler's Salts was the only formulation with near-neutral pH, suggesting a lower risk for enamel erosion. These findings highlight the importance of dental risk awareness among pediatricians and caregivers. Incorporating preventive practices, such as oral rinsing after medication and regular dental consultations, can play a pivotal role in mitigating long-term oral health consequences in children.

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