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# Morphological analysis of the bristles from toothbrushes sold in the Peruvian market, using scanning electron microscopy. Part II – Pediatric toothbrushes

Análise morfológica das cerdas de escovas de dentes comercializadas no mercado peruano por microscopia eletrônica de varredura. Parte II – Escovas de dentes infantis

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## ABSTRACT

**Objective:** To characterize the morphology of children's toothbrushes marketed in the Peruvian market using scanning electron microscopy. **Material and Methods:** This was an observational, prospective, cross-sectional, and analytical study. Scanning electron microscopy images of bristles from 24 models of pediatric toothbrushes were analyzed, following the classification system proposed by Silverstone and Featherstone and modified by Reiter and Wetzel, using a digital tool specifically developed for this study. A descriptive statistical analysis was performed on patterns of bristle acceptability and unacceptability, along with inferential analysis of these patterns in relation to the following characterization variables: number of filaments per tuft, total number of filaments per brush, country of origin, and retail price. **Results:** The percentage of acceptable bristle tips ranged from 0% to 100%, indicating substantial variability in bristle morphology among the evaluated toothbrushes. No statistically significant associations were found between bristle acceptability and the analyzed variables. However, a moderate and statistically significant positive correlation was observed between the total number of bristles in manual toothbrushes and their retail price in Peruvian soles ($r = 0.58$, $p = 0.003$). **Conclusion:** This study revealed substantial heterogeneity in the morphology of bristles in children's toothbrushes marketed in Peru, with several models exhibiting proportions of unacceptable bristles equal to or greater than acceptable ones. In addition, although a positive association was observed between toothbrush price and bristle density, no significant relationship was found between price and bristle acceptability, indicating that higher-cost toothbrushes do not necessarily guarantee better morphological quality.

## KEYWORDS

Home care dental devices; Gingival recession; Oral hygiene; Tooth abrasion; Toothbrushing.

## RESUMO

**Objetivo**: Caracterizar a morfologia das escovas de dentes infantis comercializadas no mercado peruano por meio da microscopia eletrônica de varredura. **Material e Métodos:** Trata-se de um estudo observacional, prospectivo, transversal e analítico. Foram analisadas imagens de microscopia eletrônica de varredura das cerdas de 24 modelos de escovas de dentes pediátricas, seguindo o sistema de classificação proposto por Silverstone e Featherstone e modificado por Reiter e Wetzel, utilizando uma ferramenta digital desenvolvida especificamente para este estudo. Foi realizada uma análise estatística descritiva dos padrões de aceitabilidade e inaceitabilidade das cerdas, bem como uma análise inferencial desses padrões em relação às seguintes variáveis de caracterização: número de filamentos por tufo, número total de filamentos por escova, país de origem e preço de mercado. **Resultados:** A porcentagem de pontas de cerdas aceitáveis variou de 0% a 100%, indicando uma variabilidade substancial na morfologia das cerdas entre as escovas de dentes avaliadas. Não foram encontradas associações estatisticamente significativas entre a aceitabilidade das cerdas e as variáveis analisadas. No entanto, observou-se uma correlação positiva moderada e estatisticamente significativa entre o número total de cerdas das escovas de dentes manuais e o preço de mercado, na unidade monetária local ($r = 0,58$, $p = 0,003$). **Conclusão:** Este estudo revelou uma heterogeneidade substancial na morfologia das cerdas das escovas de dentes infantis comercializadas no Peru, com vários modelos apresentando proporções de cerdas inaceitáveis iguais ou superiores às aceitáveis. Além disso, embora tenha sido observada uma associação positiva entre o preço da escova de dentes e a densidade das cerdas, não foi encontrada relação significativa entre o preço e a aceitabilidade das cerdas, indicando que escovas de dentes de custo mais elevado não garantem, necessariamente, melhor qualidade morfológica.

## PALAVRAS-CHAVE

Dispositivos para o cuidado bucal domiciliar; Retração gengival; Higiene bucal; Abrasão dentária; Escovação dentária.

## INTRODUCTION

Poor oral hygiene in early childhood is a major public health concern, as it represents one of the main risk factors for the development of dental caries [1,2]. Dental caries can negatively affect children's growth and development, causing pain, discomfort, feeding difficulties, weight loss, and impairing their quality of life [2,3], including psychosocial aspects [4] and masticatory performance [5].

According to the World Health Organization (WHO), between 60% and 90% of school-aged children experience dental caries, particularly in disadvantaged populations [6]. In Peru, the prevalence of dental caries among schoolchildren aged 3 to 15 years reaches 85.6%, reflecting the significant burden of this disease in the country [7].

The prevention of dental caries in children largely depends on establishing a daily routine of toothbrushing with fluoride toothpaste appropriate for their age [1]. International professional consensus indicates that toothbrushing should begin with the eruption of the first tooth and be performed at least twice a day, including once before bedtime, under parental supervision [8]. These recommendations are consistent with current pediatric guidelines, which also emphasize the importance of regular toothbrushing and the use of fluoridated toothpaste for caries prevention [9].

The effectiveness of this practice depends on the proper use of oral hygiene devices and their ability to remove dental biofilm [10]. The toothbrush is the primary tool for this purpose and, in many cases, the most widely used method for dental biofilm control [11-15].

However, improper use of a toothbrush may cause adverse effects on both soft and hard oral tissues, including gingival and dental abrasions, bristle impaction, and ulcerations. These effects are associated with brushing technique, toothbrush characteristics, and toothpaste composition, requiring special attention in pediatric populations [16,17]. Children with limited manual dexterity often perform horizontal brushing movements, which, although effective in dental biofilm removal, may increase the risk of abrasions [18]. One contributing factor to this risk is bristle morphology; therefore, current evidence and clinical recommendations emphasize that bristle tips should be rounded and free of sharp edges to minimize the risk of soft tissue injury [19-24].

Internationally, several institutions establish regulatory frameworks for toothbrush production. For example, the Food and Drug Administration (FDA, United States) and the European Union Medical Device Regulation (EU-MDR) classify manual toothbrushes as Class I medical devices (lowest risk). Similarly, in countries such as Canada, toothbrushes are considered low-risk health devices [25]. In addition, the ISO 20126:2022 standard [26] specifies technical requirements for manual toothbrushes, including that bristle tips should be rounded and free of imperfections. In Peru, there is a wide range of toothbrushes available for children at different stages of development. However, as over-the-counter products, they are not subject to specific technical standards regulating their characteristics, but only to general guidelines established by the Ministry of Health (MINSA, by its Spanish acronym). Furthermore, the General Directorate of Medicines, Supplies and Drugs (DIGEMID, by its Spanish acronym) [27] does not require mandatory registration or health notification for these products.

In this context, evaluating the quality of toothbrush bristles available in the national market becomes particularly relevant. However, to date, no evaluation has been conducted in Peru regarding the degree of bristle tip rounding in children's toothbrushes. The only prior study with this focus was conducted by Lopez et al. [28], corresponding to Part I of the present study, which analyzed adult toothbrushes and reported a high frequency of unacceptable bristles. This finding highlights the need to investigate this characteristic in children's toothbrushes as well, due to its relevance to oral health. Accordingly, this study aims to characterize the morphology of children's toothbrushes sold in the Peruvian market using scanning electron microscopy.

## MATERIALS AND METHODS

### Toothbrush selection

This study was conducted at the Scanning Electron Microscopy Laboratory of the Universidad de Huánuco during the year 2025. Prior to initiating the study, a survey was conducted to identify children's toothbrushes available in the local market. For this purpose, various drugstores, supermarkets, and wholesale stores in the city of Huánuco were visited during January and February, with the aim of identifying and selecting all toothbrush models available for each stage of childhood from different commercial brands.

Following the initial screening, 24 toothbrushes were acquired, with one unit selected from each identified model. Detailed information about each toothbrush, including brand name, intended age group, country of origin, place of purchase, price, number of tufts, number of filaments per tuft, and total number of filaments per toothbrush, is presented in Table I.

## Sample preparation

A trained examiner prepared the toothbrush samples from the selected brands, assigning numerical codes according to Table I. One tuft was randomly chosen from each toothbrush, and its filaments were carefully trimmed using a No. 15 scalpel, taking care not to alter their original shape.

The trimmed filaments were mounted onto aluminum stubs using carbon adhesive discs and examined under a Thermo Scientific Prisma E scanning electron microscope, operating under low vacuum conditions at 75 Torr and 30 kV. The microscope was set to a 2 mm magnification with a 90° viewing angle relative to the longitudinal axis of the filaments.

## Morphological analysis of toothbrush filaments

The morphology of the filament tips was assessed using the classification system proposed by Silverstone and Featherstone [29], as modified by Reiter and Wetzel [30] (Figure 1). In this system, bristles with adequately rounded tips were considered acceptable and further divided into three categories (A1–A3). In contrast,

**Table I – Characteristics of the toothbrushes**

| Toothbrush | Origin | Place of purchase | Retail price (in Peruvian Soles) | Number of tufts | Number of bristles per tuft | Total of bristles per brush |
|---|---|---|---|---|---|---|
| Neopan® 0 to 2 yrs | China | Supermarket | 9.9 | 23 | 60 | 1,380 |
| Neopan® 2 to 5 yrs | China | Supermarket | 9.9 | 23 | 68 | 1,564 |
| Neopan® 6+ yrs | China | Supermarket | 9.9 | 30 | 72 | 2,160 |
| Vitis Baby 0 to 2 yrs | Spain | Drugstore | 16.5 | 26 | 154 | 4,004 |
| Vitis Kids 3 to 5 yrs | Spain | Drugstore | 16.5 | 20 | 100 | 2,000 |
| Vitis Junior 6+ years | Spain | Drugstore | 16.5 | 29 | 54 | 1,566 |
| Aquafresh Little Teeth 3 to 5 yrs | India | Supermarket | 12.9 | 26 | 70 | 1,820 |
| TotalDent kids 3+ yrs | China | Drugstore | 7.9 | 28 | 34 | 952 |
| Oral B® Stages 0 to 2 yrs | USA | Supermarket | 13 | 32 | 56 | 1,792 |
| Oral B® Stages 3+ yrs | USA | Supermarket | 13 | 33 | 60 | 1,980 |
| Oral B® Kids 3+ yrs | Mexico | Drugstore | 4.3 | 33 | 50 | 1,650 |
| Oral B® Stages 5 to 7 yrs | USA | Drugstore | 13 | 33 | 60 | 1,980 |
| GUM® Crayola 5+ yrs | China | Drugstore | 9 | 25 | 64 | 1,600 |
| Tuinies® Kids 2+ yrs | China | Drugstore | 3 | 29 | 44 | 1,276 |
| Tuinies® Kids 3+ yrs | China | Drugstore | 3 | 28 | 42 | 1,176 |
| Condor Baby 0 to 2 yrs | Brazil | Drugstore | 5.3 | 24 | 84 | 2,016 |
| Condor Kids 2 to 4 yrs | Brazil | Drugstore | 5.3 | 23 | 58 | 1,334 |
| Colgate® Baby 2+ yrs | China | Supermarket | 11.5 | 22 | 56 | 1,232 |
| Colgate® Infantil 2+ yrs | Vietnam | Drugstore | 4.5 | 28 | 68 | 1,904 |
| Colgate® 2 to 5 yrs | China | Supermarket | 8.6 | 24 | 60 | 1,440 |
| Colgate® 5+ years | Vietnam | Wholesale market | 4.5 | 29 | 62 | 1,798 |
| Colgate® 6+ years | China | Supermarket | 11.5 | 27 | 70 | 1,890 |
| Dentito® 2 a 6 yrs | Peru | Wholesale market | 3.2 | 27 | 26 | 702 |
| D´Lucas® | Not specified | Wholesale market | 2 | 24 | 24 | 576 |

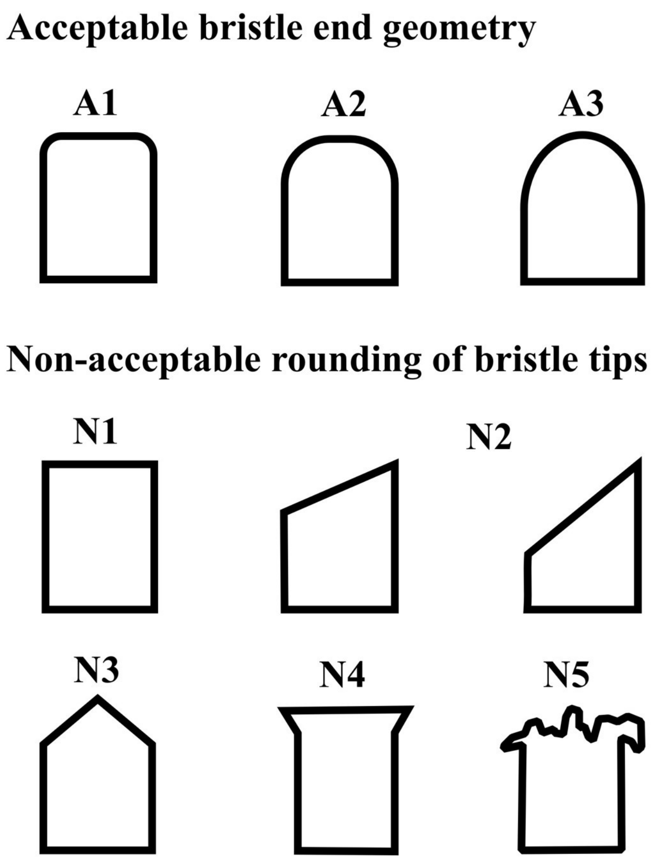


**Figure 1 -** Classification of toothbrush bristle tip morphology according to Silverstone and Featherstone [29], modified by Reiter and Wetzel [30].

bristles with features such as sharp edges, sharp rectangular tips, sharp oblique tips, triangular tips, or protruding plastic material were categorized as unacceptable and classified into five subcategories (N1–N5) (18).

This classification system was digitized through the development of a web application called "CerdasCheck," [31]. The tool allowed users to upload microscopic images in their original format (TIF) and overlay them with various classification pattern icons corresponding to the Silverstone and Featherstone [29] system, as modified by Reiter and Wetzel [30]. These icons could be resized without distortion to fit the tip of each filament analyzed (Figure 2).

The reliability of the digital instrument was assessed through repeatability (intra-observer) and reproducibility (inter-observer) testing, using 10 scanning electron microscopy images of toothbrush bristles that were not part of the main study sample. For repeatability, the principal investigator (P.A.L.B), who had prior experience in bristle morphology classification, classified the images on two separate occasions, with a two-week interval between assessments, yielding very high agreement (Kappa = 0.956). For reproducibility, a second investigator (E.A.A.C) independently classified the same 10 images. The classifications performed by the principal investigator were considered the reference standard for the assessment of interexaminer agreement, and substantial agreement was observed (Kappa = 0.766).

To minimize bias related to brand recognition and ensure analytical impartiality, all samples were coded and remained blinded throughout the evaluation. Image analysis was performed by a researcher who was not involved in the sample preparation process and who possessed full knowledge of the morphological classification system and the use of the CerdasCheck program.

To standardize the number of filaments analyzed per microscopic image, the image containing the fewest fully visible filaments—ten—was used as a reference. Accordingly, the first ten fully visible filaments were selected and evaluated from each image, beginning from the

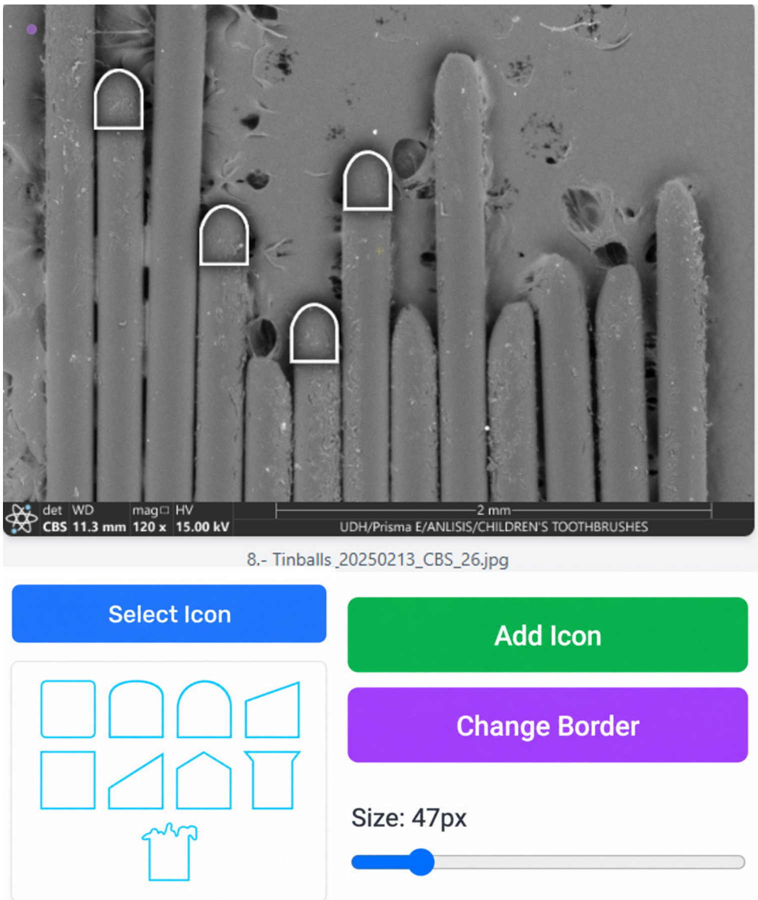


**Figure 2 -** Microscopic image of bristles from pediatric toothbrushes analyzed using the CerdasCheck program. Filaments with rounded tips classified as acceptable are observed, identified using superimposed icons based on the classification by Silverstone and Featherstone [29], modified by Reiter and Wetzel [30].

far left and proceeding sequentially until the predetermined count was reached.

### Statistical analysis

Data were processed and analyzed using Stata® 19 software (StataCorp LP, College Station, TX, USA). A stacked bar chart was used to illustrate the distribution of bristle quality across toothbrushes. The Pearson correlation coefficient was applied to assess the relationship between the total number of bristles and retail price. Fisher's exact test and Student's t-test were used to examine the association between bristle acceptability and both country of origin and sale price, respectively. A significance level of 5% was established for all statistical tests.

## RESULTS

A total of twenty-four pediatric toothbrush models sold in Peru were analyzed, revealing considerable variability in country of origin, place of purchase, price, and technical characteristics (number of tufts, filaments per tuft, and total number of filaments per toothbrush). Most of the toothbrushes originated from China (9 out of 24), followed by models from the United States, Spain, and other countries. Prices ranged from 2.00 to 16.50 Peruvian soles, with the most expensive brushes being the Vitis® models (Spain), sold exclusively in drugstores, while the least expensive were local brands or those with unspecified origin, typically purchased in wholesale markets. Regarding technical specifications, a wide range of bristle densities was observed. The model with the highest total number of filaments was the Vitis Baby 0–2 years, containing 4,004 bristles, while the D'Lucas® model had the lowest count, with only 576 bristles.

Figure 3 illustrates the distribution of acceptable and unacceptable bristle quality among various commercially available pediatric toothbrushes, categorized by brand and intended age group. A substantial proportion of toothbrushes—particularly those from brands such as Oral-B®, Aquafresh®, TotalDent®,

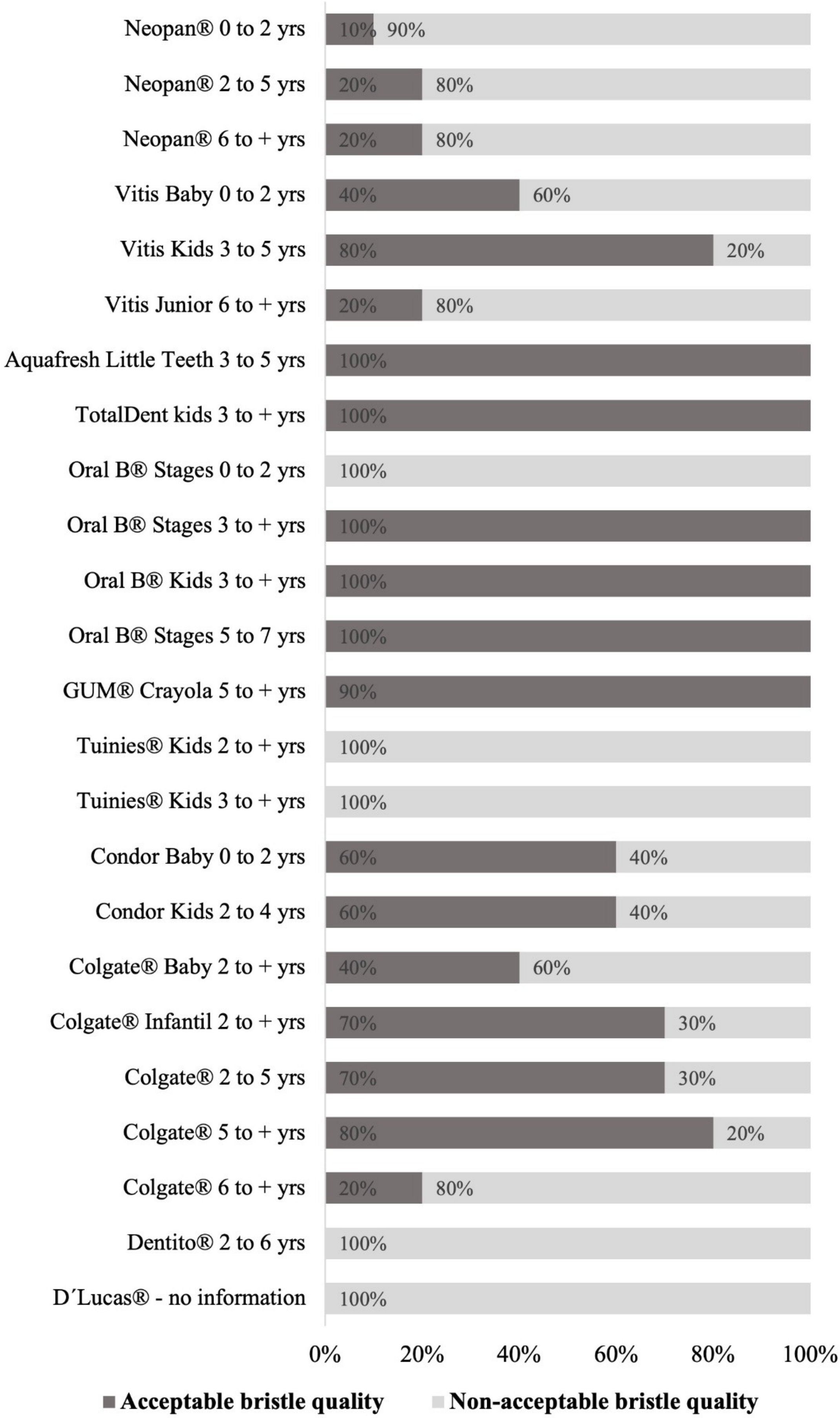


**Figure 3 -** Distribution of acceptable and non-acceptable bristle quality in pediatric toothbrushes according to brand and age group.

GUM® Crayola, and Colgate® (2–5 years and 5+ years)—demonstrated 100% acceptable bristle quality, indicating compliance with recommended manufacturing standards. In contrast, significant deficiencies were identified in certain products. Dentito® (2–6 years) and Vitis Junior (6+ years) exhibited the highest proportions of unacceptable bristle quality, at 90% and 80%, respectively. Similarly, certain models from Neopan®, Vitis Baby, and Condor® showed up to 40% of bristles classified as unacceptable. These findings highlight substantial variability in product quality across brands and age-specific designs.

A moderate and statistically significant positive correlation was observed between the total number of bristles in manual toothbrushes and their retail price in Peruvian soles, determined using Pearson's correlation coefficient ($r = 0.58$, $p = 0.003$). As shown in Figure 4, toothbrushes with a higher number of bristles tended to be more expensive, a relationship reflected in the upward trend of the fitted regression line.

No statistically significant associations were found between the acceptability of pediatric toothbrushes and the evaluated characteristics (Table II). While a higher proportion of unacceptable toothbrushes originated from China (58.3%), the difference was not statistically significant (Fisher's exact test, $p = 0.215$). Similarly, no significant differences were observed regarding place of purchase (Fisher's exact test, $p = 0.373$), even though acceptable toothbrushes were more frequently purchased from drugstores (66.7%). No significant differences were found in average retail price (Student's t-test, $p = 0.827$) or in the total number of bristles per toothbrush (Student's t-test, $p = 0.726$) between the acceptable and unacceptable groups. These results suggest that the evaluated variables are not significantly associated with the acceptability of bristle quality.

## DISCUSSION

This study aimed to characterize the morphology of bristles in children's toothbrushes sold in the Peruvian market using scanning electron microscopy. The results revealed a wide variability in filament morphology, with acceptability rates ranging from 0% to 100%, according to the Silverstone and Featherstone [29] classification, as modified by Reiter and Wetzel [30]. While some models fully met the acceptability criteria, others showed no compliance at all.

This finding is particularly concerning in light of current evidence, which highlights the importance of rounded bristle tips to reduce the risk of gingival abrasions [20,21,23,24]. In this context, Hennequin-Hoenderdos et al. [20] suggested that a minimum rounding level between

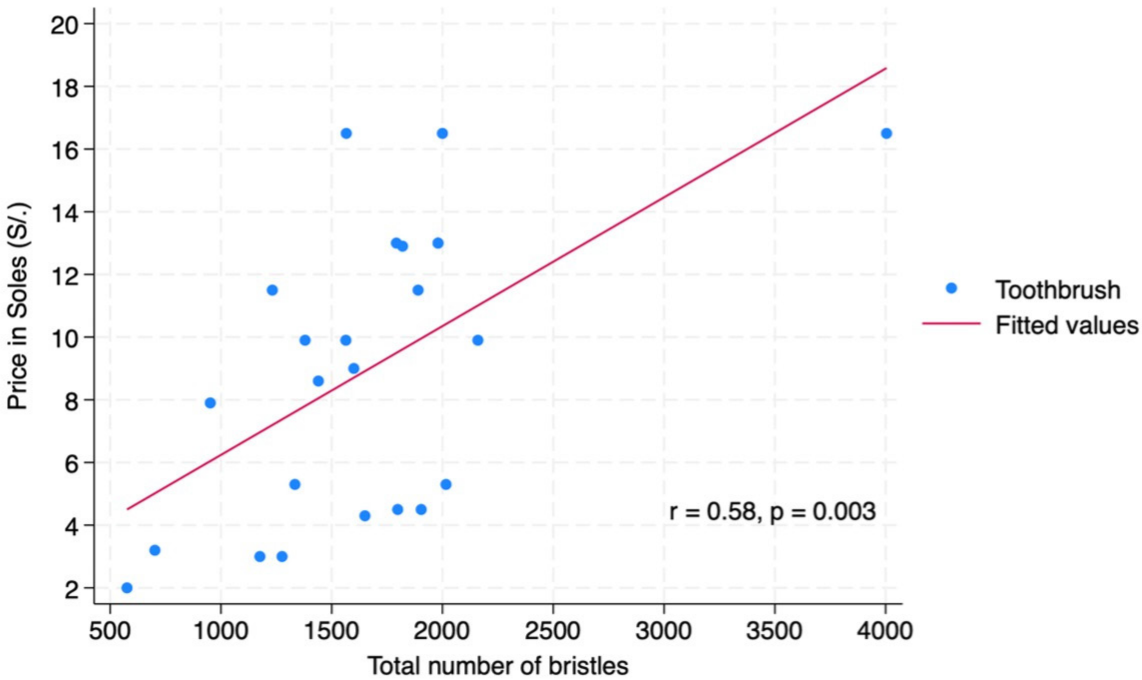


**Figure 4 -** Correlation between bristle count and toothbrush price in Peruvian soles, showing a positive relationship (Pearson's r = 0.58, p = 0.003).

**Table II – Association between toothbrush characteristics and bristle acceptability**

| Characteristics | | Acceptability | | P |
|---|---|---|---|---|
| | | Yes (n=12) n (%) | No (n=12) n (%) | |
| Origin | | | | 0.215† |
| | China | 7 (58.33) | 3 (25) | |
| | Spain | 2 (16.67) | 1 (8.33) | |
| | India | 0 | 1 (8.33) | |
| | USA | 1 (8.33) | 2 (16.67) | |
| | Mexico | 0 | 1 (8.33) | |
| | Brazil | 0 | 2 (16.67) | |
| | Vietnam | 0 | 2 (16.67) | |
| | Peru | 1 (8.33) | 0 | |
| | Not specified | 1 (8.33) | 0 | |
| | | | | |
| Place of purchase | | | | 0.373† |
| | Supermarket | 6 (50.0) | 3 (25.0) | |
| | Drugstore | 4 (33.33) | 8 (66.67) | |
| | Wholesale store | 2 (16.67) | 1 (8.33) | |
| | | | | |
| Retail price (S/)* | | 9.15 ± 1.50 | 8.73 ± 1.21 | 0.827‡ |
| | | | | |
| Total of bristles per brush* | | 1609.83 ± 254.33 | 1706.16 ± 94.76 | 0.726‡ |

* Mean[MF1.1] ± Standard deviation. † Fisher's exact test ‡ Student's t-test

40% and 50% is necessary to achieve this objective, while Yildiz Telatar et al. [23] emphasized that the proportion of bristles with acceptable morphology should exceed that of unacceptable ones to minimize the risk of soft tissue injury.

These results are consistent with previous studies conducted in different countries, which have reported substantial variability in bristle acceptability, with several commercially available toothbrush models failing to meet the recommended standards for bristle tip rounding [12,18,19,23,32-34].

Previous studies evaluating children's manual toothbrushes have reported considerable variation in the proportion of acceptable bristles. Turgut et al. [12] found acceptability rates ranging from 18.9% to 60.3% in children's toothbrushes. Similarly, Gemperle et al. [17] reported percentages between 5.6% and 45.6%, while Lee et al. [18] documented values as low as 1.4% to 20.2% in pediatric models. In line with these findings, the present study also identified substantial variability in bristle acceptability among the evaluated toothbrushes, with values ranging from completely unacceptable to fully acceptable models. This greater variability compared to previous reports may be explained by differences in manufacturing processes across brands, particularly those related to the grinding and end-rounding of bristles, which influence the quality of bristle finishing and may lead to inconsistencies in bristle tip morphology, as achieving uniformly rounded filament ends can be technically challenging due to differences in toothbrush design [18].

This variability reflects marked differences in manufacturing quality among toothbrushes available on the market and underscores the importance of monitoring bristle morphology in products intended for children. From a clinical perspective, while some toothbrushes meet recommended standards for bristle tip morphology, others may present characteristics that increase the risk of soft tissue injury during toothbrushing.

In this context, the wide variety of toothbrushes available on the market, differing in color, shape, material, design, and price [17], and often marketed as superior in dental biofilm removal effectiveness, may create confusion among consumers and highlights the importance of professional guidance in the selection of appropriate oral hygiene devices [12,33]. Furthermore, current standards and evidence regarding suitable filament types and bristle tip morphology classifications [24,29,30,32] raise concerns about whether commercially available products consistently meet these standards. This issue may be particularly relevant in pediatric populations, where children have not yet developed the manual dexterity required for optimal brushing technique. Therefore, minimizing potential risks associated with toothbrushing remains an important consideration in this age group [12,17,18,33,35].

In addition to the variability observed in bristle acceptability, methodological differences—particularly regarding the viewing angle used in microscopic analyses—should also be considered when interpreting results. The present study employed a 90° perpendicular angle, consistent with the original Silverstone and Featherstone [29] classification as modified by Reiter and Wetzel [30], allowing direct comparison with these criteria. However, other authors, such as Meyer-Lueckel et al. [34] and Jung et al. [35], have proposed using 45° angles, which allow the evaluation of a greater number of filaments within a tuft but may alter the perception of bristle tip morphology compared with the reference classification. These methodological differences may influence reported acceptability rates and highlight the importance of standardized evaluation methods when assessing the morphology of toothbrush bristles.

This investigation also enabled an economic analysis of pediatric toothbrushes. A price gradient ranging from 2.00 to 16.50 Peruvian soles was identified, which was directly proportional to bristle density ($r = 0.58$, $p = 0.003$). This relationship could be partially explained by studies describing the structural characteristics of toothbrush bristles. Bristle stiffness varies according to filament diameter; soft toothbrushes typically have thinner filaments, which allow a greater number of filaments to be packed within each tuft [36-38]. Axe et al. [39] reported in an *in vitro* study that such structural characteristics may contribute to improved dental biofilm removal performance. However, despite these experimental findings, there is currently limited clinical evidence demonstrating that toothbrushes with a higher number of filaments provide superior dental biofilm removal or improved oral hygiene outcomes. Consequently, while brushes with higher filament density may involve more complex design and manufacturing processes, which could partially explain their higher market price, the clinical advantages of this feature remain unclear.

This price variation may have relevant implications for access to oral hygiene products. For a low-income family (monthly income of 1,695.20 Peruvian soles) [40], this implies allocating approximately 1% of their income solely for the annual purchase of toothbrushes, a financial burden that increases when considering the recommended quarterly replacement. National [41] and multiethnic [25] studies confirm that cost is a barrier to accessing quality toothbrushes in vulnerable populations. However, although price was found to be associated with bristle density, no statistically significant association was observed between price and bristle acceptability. This finding suggests that a higher cost does not necessarily guarantee superior morphological quality. Therefore, identifying which commercially available toothbrushes meet acceptable technical criteria becomes particularly important in order to recommend affordable and safe options, especially in contexts of relative poverty.

Among the strengths of this study is the inclusion of toothbrushes for all stages of childhood and all brands available in the local market, exceeding the number of models evaluated in previous research [12,17,18]. Additionally, low-vacuum scanning electron microscopy was used, which avoids metal coating and preserves the original filament morphology [42]. A custom-developed web application was also employed to reduce observer bias, in line with similar strategies used by Turgut et al. [12]. This digital tool helped reduce the subjectivity inherent in the Silverstone and Featherstone [29] classification as modified by Reiter and Wetzel [30]. However, this system has been criticized in the literature for relying on two-dimensional images [34] and for difficulty in categorizing atypical morphologies [18,35], a limitation also encountered in this study.

A key limitation of this study was the sample size, as only one unit per model and ten filaments per brush were analyzed. This design may limit the ability to capture intra-brand or batch variability. Studies by Meyer-Lueckel et al. [34] and Gemperle et al. [17] used five brushes per brand with stratified sampling to achieve greater representativeness.

## CONCLUSIONS

The present study demonstrated substantial variability in the morphology of bristles in children's toothbrushes sold in the Peruvian market. According to the classification by Silverstone and Featherstone [29], modified by Reiter and Wetzel [30], the proportion of unacceptable bristles in several models was comparable to or even higher than that of acceptable bristles. These findings indicate that not all commercially available pediatric toothbrushes meet recommended bristle tip morphology criteria.

In addition, a positive association was observed between toothbrush price and bristle density; however, no significant relationship was found between price and bristle acceptability. This suggests that higher-cost toothbrushes do not necessarily guarantee better morphological quality of bristles, emphasizing the need to evaluate the characteristics of commercially available toothbrushes intended for children.

### Data availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

### Author's Contributions

PLB: Conceptualization, Investigation, Writing – Original Draft Preparation, Writing – Review & Editing, Project Administration and Funding Acquisition. EAAC: Investigation, Writing – Original Draft Preparation, Writing – Review & Editing. MST: Writing – Original Draft Preparation, Writing – Review & Editing, Formal analysis. CFQ: Investigation, Writing – Original Draft Preparation, Writing – Review & Editing. EJPP: Investigation, Writing – Original Draft Preparation, Writing – Review & Editing. AJSA: Investigation, Writing – Original Draft Preparation, Writing – Review & Editing. AERC: Investigation, Writing – Original Draft Preparation, Writing – Review & Editing.

### Conflict of Interest

The authors declare no personal, financial, or proprietary interests related to any product, service, and/or company mentioned in this article.

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### Regulatory Statement

This study was exempted from review by the local ethics committee, since it did not involve the participation of any volunteers, or the use of any human material.

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