

PUBLIC PERCEPTION ON THE USE OF ECO-FRIENDLY BAMBOO TOOTHBRUSH

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Abstract

Plastic toothbrushes which are mainly made of polypropylene are one of the sources of plastic pollution. With the increased awareness of this alarming global issue, eco-friendly bamboo toothbrushes have been introduced and are becoming widely available in the market. The study aimed to explore the public's experience with bamboo toothbrushes and identify their feature preferences. An observational study using a qualitative approach was conducted among 10 participants aged from 18 to 40 years old without any experience using bamboo toothbrushes (based on the inclusion and exclusion criteria). A selected standard bamboo toothbrush was given to the participants and they were asked to use the bamboo toothbrush for two weeks based on the instructions provided. At the end of two weeks of usage, a one-to-one, semi-structured in-depth interview was conducted either face-to-face or online. These interviews were recorded, transcribed and analysed using thematic analysis. Most participants expressed mixed views regarding their experience using the bamboo toothbrush in comparison to their previous conventional plastic toothbrush. The most preferred features of the bamboo toothbrush cited by the participants were related to a non-slippery handle, small-sized toothbrush and eco-friendly material. The majority of the participants have the intention to continue using the bamboo toothbrush provided some modifications to the design are made. Identifying the ideal features of a bamboo toothbrush could be a timely strategy to reduce the impact of plastic in oral health care.

Keywords: Bamboo Toothbrushes; Plastic Pollution; Eco-Friendly Dental Products; Perception; Efficiency of Bamboo Toothbrushes

Introduction

In marine ecosystems all around the world, plastic pollution is recognized as a human problem due to the indestructible nature of plastics, which will persist in the environment for hundreds of years. The situation worsens when plastic output increases in general. Plastic will degrade in the ocean into tiny particles known as microplastics (< 5 mm) and nanoplastics (< 100 nm) (1). Since the first plastic toothbrush was created in the 1930s, an increasing number of them are now developed, used, and discarded annually (2). Plastic toothbrushes, which are constructed of polypropylene material, are one of the sources that contribute to plastic pollution. An estimated one billion toothbrushes are used and discarded annually in the United States alone (2).

Plastic toothbrushes, which are constructed of polypropylene material, are one of the sources that contribute to plastic pollution. Plastic toothbrushes are widely used, however, they cannot be recycled because the composite plastic they are made of is tough to degrade and frequently becomes jammed in recycling equipment (3). According to a survey on the Great Pacific Garbage Patch, 80,000 tonnes of waste plastic have been detected in Pacific latitudes, including Hawaii, with North America and Asia accounting for 54% of the debris (4). The waste composite plastics increase surface area and mobility when they age and become particle matter, which makes them easy to absorb into the food chain and fatally harms all living things (5). In response to the increased awareness of this issue, eco-friendly

toothbrushes have been introduced. One type that is gaining popularity is bamboo toothbrushes. A dentist in Brisbane created the first bamboo toothbrush, which has a handle composed of real cellulose fibre (6). Bamboo is one of the fastest-growing plants due to its high growth rate, which permits harvest cycles every three to five years without negatively impacting the environment (7).

Furthermore, because it doesn't require fertilisers or pesticides to be grown, bamboo is regarded as a low-impact crop. Because of this, growing bamboo reduces soil erosion and water pollution, making it a more environmentally friendly option than growing conventional crops (8). Scientists have postulated that plastic buildup in the body may be hazardous, so they are offering bamboo as an alternative, as it is a form of grass, so it is natural and will not build up in your body the way plastic can and it releases no harmful chemicals into the environment (9). Long-term benefits of bamboo include helping the environment and being both durable and cost-effective (10). However, there have been few studies on bamboo toothbrushes in the limited literature.

In response to the current trend, it is timely to explore the user's experience, perspective and acceptance of bamboo toothbrushes. The findings would be valuable in providing insight into consumer experience and behaviour towards eco-friendly toothbrushes, supplying input to the industry and filling the gap in the literature.

Materials and Methods

Study design, study population and sampling procedures

The study was granted ethical clearance by the Medical Ethics Committee, Faculty of Dentistry, Universiti Malaya [DF RD2210/0050]. This was a qualitative study involving in-depth interviews among adults aged 18 to 40 years old. The young and middle-aged adults were chosen for this study because they have the purchasing power to select and buy their own toothbrushes. In terms of sample selection, this study used a convenient and purposive sampling method. To ensure heterogeneity of the samples, they were chosen to represent different age groups, genders and ethnicities in Malaysia. The eligibility of the participants are based on several inclusions and exclusions criteria. Young and middle-aged adults aged 18 to 40 years old were identified. To be eligible for the study, participants must be mentally fit and

use conventional manual plastic toothbrushes, and have access to smartphones and WhatsApp application. Participants who are using something other than a standard manual plastic toothbrush such as an electric toothbrush and are not fluent in Bahasa Melayu or English were excluded from this study. Those who were denture users or had extensive fixed prostheses were also excluded.

Data collection

A selected standard bamboo toothbrush from the same manufacturer (without label/anonymised) was given to the participants to be used twice daily for 2 weeks. The toothbrush provided is illustrated in Figure 1. To articulate the justification for using this bamboo toothbrush, the researchers considered the basic design of a toothbrush that equates to the conventional plastic toothbrush in which the nylon bristles are flat and the handle is straight with no gripping feature, to lay a fundamental ground on the users' perceptions of using the provided bamboo toothbrush. Apart from that, the design is also widely available as other customary natural bamboo toothbrushes.



Figure 1: Bamboo toothbrush provided to participants (From left: back view, side view, front view)

Participants were instructed to hang dry the toothbrush after each use to prevent fungal growth and to take photos of the bamboo toothbrush that they received before use side by side with their previously used toothbrush on a background of an A4 paper from four views as a baseline image. They were also instructed to take photos of their used bamboo toothbrushes using smartphones after week 1 and week 2 as taken at baseline and send them to the investigators via Whatsapp. The purpose of the images was to ensure participants used the given bamboo toothbrushes and were able to provide insights during the interview. The images were evaluated using the toothbrush wear rate as shown in Table 1. The toothbrush wear rate is cited from an article by Rawls et al. (11)

Table 1: Evaluation of toothbrush wear rate.

Score	Standard
0	Not used. There is no spreading in the bristles.
1	Some bristles spread in a bundle of bristles.
2	The entire bristle spreads in a bundle of bristles. Multiple overlaps with each other.
3	Most bristles are tangled and tilted.

A pilot study was conducted on two participants and the interview questions were re-evaluated and modified where deemed necessary. After two weeks, a semi-structured in-depth interview with participants was conducted by trained interviewers (ASR, FIMH) either face-to-face or online; following the wear rate assessment (only score 1 and above will be interviewed). Participants who did not use the bamboo toothbrush for two consecutive weeks were also interviewed, given that their wear rate assessment is a score of 1 and above. The interview was conducted in Bahasa Melayu or English based on the participant's preference using the interview guide prepared with a set of probing questions to prompt an elaborative response. The interview guide was prepared based on the objectives of this research and citing some questions from an almost similar research by Pilcher et al. (13). Table 2 outlines the interview guide prepared. All interviews were recorded using a DJI Pocket 2 which is a pocket-sized camera and a smartphone with prior consent from the participants.

Data analysis

A total of 10 participants were interviewed based on thematic saturation, where new data no longer contribute to new findings (12). Initially, it was estimated up to 16 participants would be interviewed. However, due to the complexity of getting participants and time constraints, a decision was made to conduct 10 interviews as it was judged that sufficient saturation of themes had been reached. Potential drawbacks associated with a small sample size include limited scope for comparison and the possibility of underrepresentation or overrepresentation of data. The audio recording of each interview was transcribed verbatim in Microsoft Word format and verified by another researcher. The responses in Bahasa Melayu were translated into English using the communicative translation method. The conceivable limitation of this is contextual

challenges as some words or phrases may have different meanings depending on the context, making accurate translation challenging. A copy of the transcription was sent to the participants to confirm their responses. All the data gathered from the interviews were analysed using thematic analysis. Triangulation of the data was done using the transcribed data, field notes and patient feedback. To prevent misinterpretation and bias, the codes were developed and reviewed by more than one researcher. The themes were derived from finding the parallels in the way a topic is discussed or written about and interpreting them accordingly.

Results

Participants' demographic

To ensure the heterogeneity of the sample, participants from different ethnicities were selected (Table 3). Out of 10 participants interviewed, only one participant did not complete the two-week course of using the bamboo toothbrush allocated as the participant found it difficult to adapt to using the bamboo toothbrush and had a gagging reflex when brushing the palatal surfaces of the maxillary teeth. Three domains were generated from the interviews: (a) User's experience (b) Feature preference and (c) Intention to continue using the bamboo toothbrush. Each domain consists of themes that were summarised and presented using figures.

Domain 1: User's experience

Four themes were identified among the responses: a) Comfort b) First impression c) Self-perceived cleanliness and gum health d) Toothbrush storage, with their respective sub-themes as illustrated in Figure 2.

a) Comfort

The responses from the participants regarding comfort were divided into two sub-themes: a) Handle of toothbrush b) Bristles of the toothbrush. Although several participants were satisfied with the comfort provided by the toothbrush, some concerns developed as quoted:

Table 2: Interview guide used during the interview.

Objectives	Main questions	Probing questions
Experience	How long did you use the bamboo toothbrush?	How many times per day?
	Did you stop using the bamboo toothbrush before the 2-week duration?	If yes, when did you stop and what was the reason?
	How did you feel about using the bamboo toothbrush?	<ul style="list-style-type: none"> a) Were there any differences compared to your previous plastic toothbrush? b) Do you feel your teeth clean after using the bamboo toothbrush? c) Was the bamboo toothbrush comfortable? If not, what is the reason? d) Were there any problems or issues when using the bamboo toothbrush?
	Are there any differences in your oral hygiene practice when using bamboo toothbrushes?	Any practice that you find difficult with a bamboo toothbrush?
Features	a) Are there any features that you like regarding the bamboo toothbrush? What do you like the most?	Handle What do you think about the bamboo toothbrush handle?
	b) Are there any features that you dislike regarding the bamboo toothbrush? What do you dislike the most?	Bristle What type of bristles were your previous toothbrush?
		Head <ul style="list-style-type: none"> a) What is your opinion on the head of the bamboo toothbrush? b) Any difference as compared to your previous plastic toothbrush?
		Design What do you think about the bamboo toothbrush design?
		Toothbrush storage What do you think about the toothbrush storage of bamboo toothbrushes, compared to plastic toothbrushes?
Intention to continue use	Will you continue using the bamboo toothbrush? Why?	<ul style="list-style-type: none"> a) Preference between plastic vs bamboo toothbrushes. Why? b) Would you recommend using a bamboo toothbrush to your family and friends? Why?
Criteria in choosing toothbrush	How do you choose your toothbrush?	<ul style="list-style-type: none"> a) Does the size of the toothbrush head matter to you and why? b) Is price one of the factors when you choose your toothbrush? c) Are bamboo toothbrushes available in your local store? Where do you usually see them? d) Does the brand of toothbrush affect your choice?

Table 3: Demographic data of participants

Ethnicity	Gender	
	Male	Female
Malay	2	4
Chinese	1	1
Indian	0	2
Total	10	

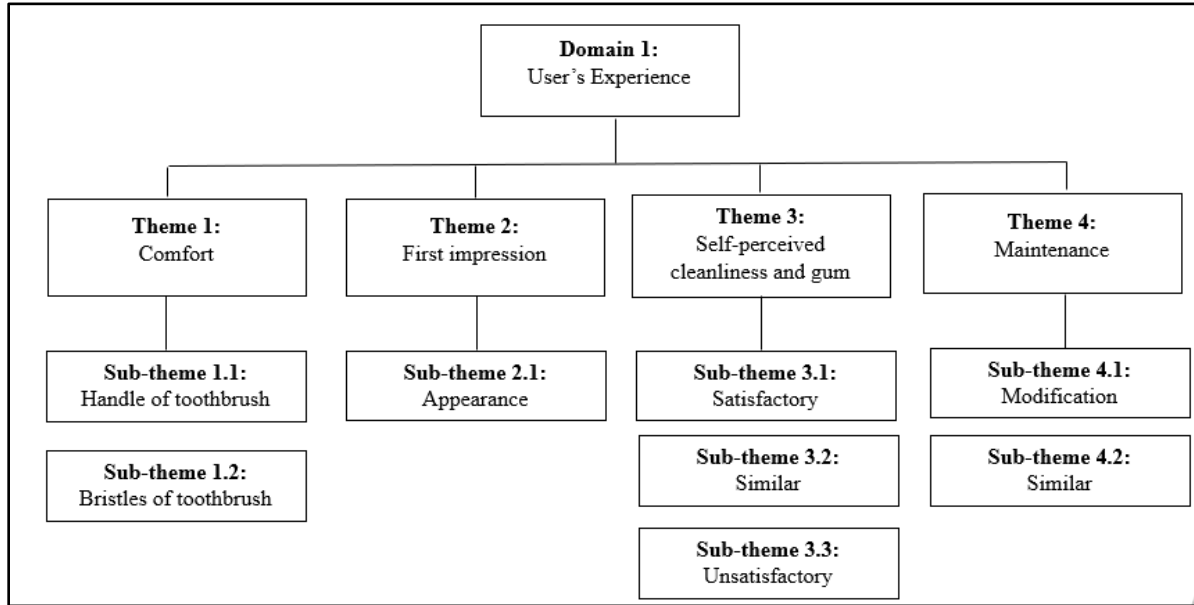


Figure 2: User’s experience on using bamboo toothbrush

“During brushing, the handle will stick to the mucosa if the mucosa is dry. Thus, it causes the mucosa to hurt a bit.” (38, Indian, Female).

“It is not very comfortable as it is too soft.” (23, Malay, Female).

b) First impression

Two participants expressed their first impression of the appearance of the bamboo toothbrush upon receiving it, as cited:

“When I first saw the toothbrush, I thought that the toothbrush is very unique.” (23, Malay, Female).

“At first I was kind of pessimistic about it, I mean the way that I looked at the brush, it is quite different from the usual brush.” (23, Malay, Female).

c) Self-perceived cleanliness and gum health

The majority were satisfied and some participants felt the similarities in their self-perceived teeth cleanliness after brushing when comparing the bamboo and their previous plastic toothbrush, per the quote:

“After that it felt clean, clear.” (30, Malay, Female).

“Yes, quite clean.” (23, Chinese, Female).

“I feel like my teeth are clean.” (23, Chinese, Male).

“I think it is okay.” (35, Malay, Female).

“So far, I don’t really feel any difference compared to my previous brushes.” (23, Malay, Female).

“The cleanliness is the same as the previous toothbrush.” (23, Malay, Female).

“So far there is no difference.” (33, Indian, Female).

“There are no major differences in cleanliness.” (46, Malay, Male).

“It felt similar.” (39, Malay, Male).

Only one participant was not satisfied with the self-perceived cleanliness, as stated:

“The head was a bit large. It’s not so easy to reach the back teeth. It feels like it's not clean.” (33, Indian, Female).

As for gum health, in comparison with their previous plastic toothbrush, several participants had reported that there had been a self-perceived improvement in which gum bleeding had reduced:

“Our gums do not bleed easily.” (23, Chinese, Male).

“It is really comfortable to brush and the gums are also not hurt.” (35, Malay, Female).

Only one participant had reported otherwise, as articulated:

“Bleeding is still present. Sometimes, when I brush my gums will bleed.” (23, Chinese, Female).

d) Toothbrush storage

Some participants reported several modifications were made in the way they maintain their toothbrushes’ hygiene. The main reason for the modifications was due to the concern of fungal growth. As per the citation:

“I just put it in my bedroom. I’m not keeping it in the washroom because I’m scared that it will get bacteria attached to it and blackened.” (23, Malay, Female).

“I’ll make sure there is no water on the toothbrush and put it in a specifically assigned glass in the bedroom. I’m scared that fungus will be present.” (46, Malay, Male)

“If I have to carry it to work, I have to hang it anywhere until it dried. Then, I placed it in my pouch. For the previous toothbrush, after using it, if we just dab it with tissue, we can just put them back into the holder, but for this one, we have to hang it first anywhere dry.” (33, Indian, Female)

“Before putting it into the glass, I separated it first as it took a longer time to dry because it is made of wood.” (39, Malay, Male)

Domain 2: Features preference

Figure 3 shows the features preference of the bamboo toothbrush which is divided into two themes: a) Desirable and b) non-desirable. In these two themes, three sub-themes will be highlighted: a) Handle b) Head c) Bristles.

a) Desirable

Handle

Some participants expressed positive feedback regarding the handle of the bamboo toothbrush. Several also highlighted its suitability for the children to use the bamboo toothbrush, as cited:

“The handle is okay, feels light and does not cause the hand to hurt or feel tired holding onto it. The handle is better than plastic.” (30, Malay, female).

“When I use the toothbrush, the handle is very firm and not slippery, you can really hold onto it well.” (23, Malay, Female).

“I think it is very useful for kids too because it is not as slippery as the plastic one.” (23, Malay, Female).

Head

The small size of the head of the bamboo toothbrush contributed to the satisfaction felt by the majority of the participants when using it, as articulated:

“The bamboo toothbrush is more comfortable as the size is smaller than the plastic toothbrush.” (23, Chinese, Female)

“The size is smaller, so it is a bit easier to handle in the mouth. I think it is more comfortable because the size is smaller than the plastic toothbrush that I used.” (23, Malay, Female).

Bristles

Several participants highlighted the positive attributes of the bristles. Some expressions include:

“The brush is not coming off from the head and it is even. So for me, I am comfortable with that.” (38, Indian, Female).

“The brush is okay and soft, so our gums do not bleed easily. I think the brush is not easily splayed as well.”
(30, Malay, Female)

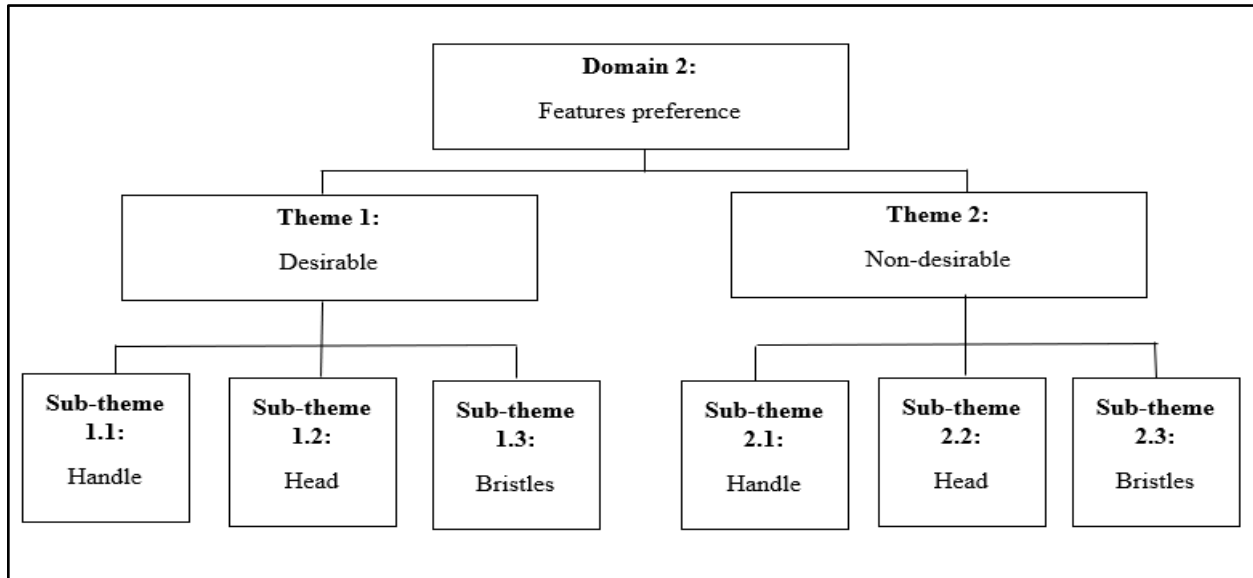


Figure 3: Features preference

“Since they are fine bristles, it is easy to enter in between teeth. The brush is not splayed, and I already used it for more than two weeks.” (35, Malay, Female).

“The brush, I feel like the bamboo one is much better.” (23, Chinese, Female).

“The toothbrush is very soft, so it is very suitable for me, who was advised by my orthodontist to use a soft-bristled toothbrush as I have a gum problem.” (33, Indian, Female)

b) Non-desirable

Despite the preferred features highlighted, some expressed dissatisfaction with certain features that might hinder them from performing toothbrushing efficiently.

Handle

The handle's rough texture and straight design are its two most noticeable unfavourable features. They expressed that it made brushing uncomfortable and painful. As quoted:

“The holder is made of wood, right? So, during brushing, if your mucosal is dry, it hurts a bit.” (38, Indian, Female).

“Compared to previous toothbrushes, the design is a bit basic.” (46, Malay, Male).

“The handle is straight and does not have a design for the comfort to hold.” (23, Malay, Female).

“The handle is too straightened. It is a bit hard to go inside.” (23, Chinese, Female).

“If the handle is in contact with water, I do not feel comfortable to hold it.” (33, Indian, Female).

Head

The participants' discontent with the head of the toothbrush can be attributed primarily to the size. Some claimed that the size was too large, making it difficult for them to properly clean their teeth. They quoted:

“It's like the toothbrush that you found in the hotels. No matter if you're a kid or an adult, the size is normal and average. Yeah, for general usage.” (23, Malay, Female).

“The head is a bit large, so it does not complement the size of the bristles which are small.” (23, Malay, female).

“The brush head is large so it is not easy to go in too deep.” (30, Malay, Female).

“The head is large, so when it touches the palate, it is not comfortable. It is also difficult to clean below the tongue.” (39, Malay, Male).

Bristles

Several participants were adversely affected by the excessive softness and not being securely attached to the head of the toothbrush. They cited:

“The brushes came out twirling as they were not firmly stuck to the head of the toothbrush.” (23, Malay, Female).

“It’s a bit too soft.” (46, Malay, Male).

“It’s too thin.” (39, Malay, Male).

Domain 3: Factors influencing the continuous use of the bamboo toothbrush

Figure 4 shows the factors influencing the participant's intention to continue using the bamboo toothbrush in the future. It is divided into four themes: a) Brand b) Price c) Availability d) Modifications needed. Brand and price are the factors that the participants consider before purchasing a toothbrush. The availability of the toothbrush and the modifications desired by the participants influenced their intention to continue using the bamboo toothbrush. Only one participant had no intention to continue using the bamboo toothbrush.

a) Brand

The majority of the participants admitted that their choice of toothbrush was influenced by the brand,

followed by family usage and brand familiarity from years of using the same product.

“Brand, too. Systema or Colgate. The one that I always used. Never try other brands yet.” (38, Indian, Female).

“I followed what my husband bought. I use what my family used” (35, Malay, Female).

“For example, if they used a certain product for a long time, then, maybe I will be affected as well by the consumption choice of my family.” (23, Malay, Female).

b) Price

The majority of respondents stated that price was a factor they would take into account when purchasing a toothbrush because they wanted a toothbrush that was both effective and reasonably priced. While some participants discussed the range of pricing they thought to be reasonable, others stressed the significance of compelling advertising.

“It is an important factor because we want a toothbrush with good effect but not too pricey.” (23, Malay, Female).

“Around below ten ringgit.” (23, Chinese, Male).

“But if the advertisement is more attractive, I won’t consider the price.” (23, Chinese, Female).

“If the difference of the price is more than three ringgit, I will consider it.” (23, Malay, Female).

c) Availability

The non-availability of the bamboo toothbrush at the local store discouraged the participants from searching through other channels.

“No, this is my first exposure, so I never searched them online.” (39, Malay, Male).

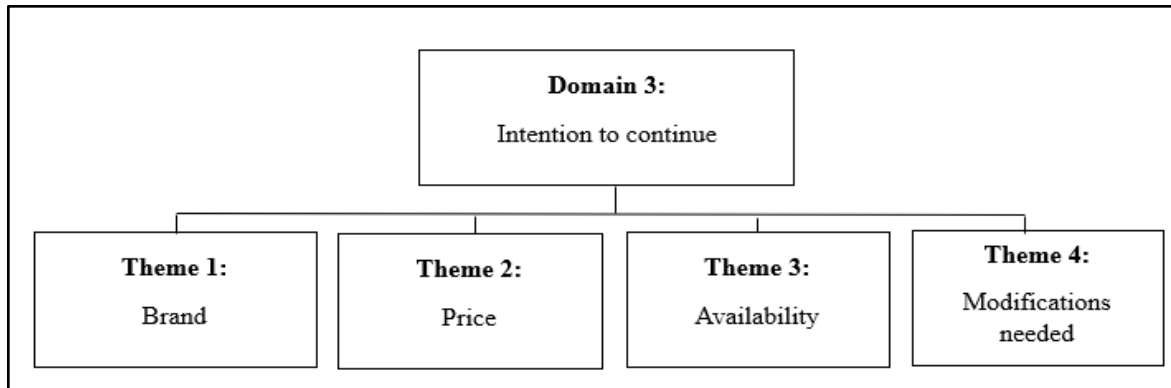


Figure 4: Intention to continue using bamboo toothbrushes.

“No, not even in the pharmacy. I don’t have the urge to find them online.” (46, Malay, Male).

“No, never seen it before. This is the first time.” (33, Indian, Female).

“I never noticed it.” (23, Malay, Female).

d) Modifications needed

Some participants said that the current bamboo toothbrush has to be modified to provide a greater or comparable level of self-perceived cleanliness satisfaction to a conventional plastic toothbrush. The modifications were quoted by the participants:

“It is better if the design is similar to the plastic toothbrush.” (46, Malay, Male).

“The bristles fill up the toothbrush head.” (30, Malay, female).

“Narrow head and quite larger at the base.” (23, Malay, Female).

“It is more important if there is a grip feature.” (46, Malay, Male).

“Make the head a bit larger with some curves.” (39, Malay, Male).

“Make it more water resistant, I think.” (33, Indian, Female).

Discussion

In this study, there are mixed views from the participants on their experience with using bamboo toothbrushes after two weeks. Generally, the participants felt comfortable using the bamboo

toothbrush because of the soft bristle and firm handle. All participants except one would like to continue using the bamboo toothbrush if several modifications were applied to make it as equally satisfying as the conventional plastic toothbrush. The primary issue with conventional plastic toothbrushes is that they contribute to the damaging plastic pollution around the globe (13). Due to the prevalence of single-use plastics in dental care, this has long proven exceedingly challenging (14).

a) User’s experience

The study found that most participants perceived the bamboo toothbrush as comfortable, citing its soft bristles as a major factor influencing their choice of toothbrush (15). However, some participants disagreed, with some preferring hard-bristled toothbrushes. A study by Opeodu et al. (16) reported that this was due to the assumption that hard bristle toothbrushes are capable of removing extrinsic staining on the teeth due to their higher coffee consumption and smoking habits. The reason for the preference for the bristle type was not determined in this study.

The study reveals that first impressions of toothbrushes are influenced by appearance and personal experience, with previous experience playing a more significant role (17). The majority did not experience bleeding gums while brushing using the bamboo toothbrush. A similar study conducted by Pilcher et al. also observed that 100% of the participants did not experience bleeding gums while brushing using a bamboo toothbrush (13), however it was a questionnaire study that limited further assessment of user satisfaction and perception of the bamboo toothbrushes.

b) Feature preference

This study found that key toothbrush features commonly cited by participants include a non-slippery handle, appropriate size of the toothbrush head, and soft bristles. A few participants highlighted that the bamboo toothbrush is suitable to be used by children for its light, firm, and non-slippery handle. This is in line with an article by Lifetime Family Dental which cited ideal features of a toothbrush for children including a toothbrush handle that is easy to hold and soft bristles that will not damage the gums (18). In this study, one participant mentioned that they were unable to reach the secondary molars using the bamboo toothbrush. A similar observation was reported by Pilcher et al. (13) in which 30% of the male participants reported that they were unable to clean the posterior teeth using the provided bamboo toothbrush.

A study in North Gujarat India reported that 70% of the female participants agreed that the bamboo toothbrush is sustainable (13). However, the eco-friendly feature of the toothbrush was less likely cited by the participants in the present study. Only a few participants expressed concern about the environmental aspects related to their toothbrush selection. In comparison to plastic products, bamboo has the lowest environmental effect, thus switching from conventional plastic toothbrushes to bamboo ones is more environmentally friendly (19).

c) Intention to continue

A person's personal preferences, such as the design of the toothbrush, might have a significant impact on their choice of the oral care product that is ideal for them (16). In the present study, the majority of the participants were accustomed to certain brands of toothbrushes. This finding could be due to their long attachment to the brand and developed trust in the products of the brand, as supported by Opeodu et al. (16) reported that 62.9% of their studied population were influenced by well-known toothbrush brands. In the present study, some participants cited that they would use the type of toothbrush that their family members had bought. Previous studies by Kote et al. (20) and Al-Omiri et al. (21) found that a greater proportion of people are affected by familial or parental influences when selecting their toothbrushes. In addition, one participant highlighted that the choice of toothbrush was influenced by advertisements. The finding was in contrast with a study by Umanah and Braimoh (22) indicating that advertisement is the least influencing factor in choosing a toothbrush.

The intention to continue using the bamboo toothbrush is also found to be influenced by the cost. In this study, many participants were concerned about the price of the toothbrush before choosing one. Cost is a major influencing factor in choosing a toothbrush according to studies by Umanah and Braimoh (22), and Awais et al. (23). A number of the participants in this study have expressed their intention to continue using the bamboo toothbrush provided that some modifications are made to fit the needs of an effective toothbrush. Some of the suggestions include an ergonomic handle and a narrow or diamond-shaped head for the toothbrush.

Conclusion

Based on this study, the participants expressed mixed views on their first experiences with the bamboo toothbrush. Some of the features highlighted by participants such as firm but non-ergonomic handles, appropriate size of toothbrush head, and soft bristles can provide insight to manufacturers on how to produce or modify their bamboo toothbrushes. Despite that, the majority of the participants are willing to continue using the bamboo toothbrush provided that improvements to the design of the toothbrush are incorporated in the future. Since bamboo is gaining popularity in the manufacturing industries of toothbrushes, more studies are needed to explore the usage of these bamboo toothbrushes for their value validation and further manipulation of their potential. Thus, encouraging the usage of eco-friendly toothbrushes may contribute to efforts towards green dentistry in reducing worldwide plastic pollution.

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Competing interests

The authors declare no conflict of interest.

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