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Utilization of toothpaste and fluoride content in toothpaste manufactured in Tanzania

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Abstract

Objective. To determine the use of toothpaste, the reasons behind its irregular use, the cost perceptions, and the fluoride concentrations in locally manufactured toothpaste. ***Material and Methods.*** A total of 978 dental patients attending 13 dental clinics for 2 weeks in June 2007 completed a pre-tested questionnaire on toothpaste use. Toothpaste was collected from shops in Dar es Salaam and analyzed at the laboratory of the Dental School in Amsterdam. Logistic regression was applied to determine the relative importance of independent variables on usage and perceptions about the cost of toothpaste. ***Results.*** Eighty-six percent of respondents used toothpaste daily. Of the 130 who used toothpaste less than once a day, 57.7% gave financial reasons for their irregular use. Toothpaste was perceived as expensive by 34.8% of respondents. Urban residents were five times more likely than rural residents to use toothpaste. Younger respondents were more likely than older respondents: to perceive toothpaste as important, to brush their teeth, to use toothpaste, and to brush their teeth regularly. All toothpaste manufactured in Tanzania had free fluoride concentrations below 400 ppm. ***Conclusions.*** Most respondents used toothpaste regularly and one-third regarded it as expensive. Toothpaste manufactured in Tanzania had free fluoride concentrations below the optimum levels for dental caries prevention. For a well-functioning Basic Package of Oral Care, the authority responsible for oral health has to take measures aimed at lowering the price of toothpaste, and toothpaste manufacturers have to ensure that their products have the optimal fluoride concentration for dental caries prevention.

Key Words: *Basic package of oral care, fluoride concentration, fluoride toothpaste, oral hygiene, Tanzania*

Introduction

Oral health care in Tanzania is rendered in dental clinics situated in regional and district hospitals. Rural residents have to travel long distances to urban centers to seek oral care, and the predominant mode of treatment is tooth extraction [1–4]. The contribution of restorative care to oral health care and to the oral health of the population is negligible [1–3,5,6] because the economy cannot support the equipment needed to supply traditional restorative care [7,8]. Atraumatic Restorative Treatment (ART) has been perceived as a suitable alternative or complementary approach to treating dental carious lesions, an approach that enables practitioners to provide restorative care in their clinics and outreach programs [9] and, in turn, improve access to oral care for rural and suburban populations.

Consequently, ART was introduced in 16 pilot clinics in July 2005. Practitioners working in these clinics were given the required knowledge and trained in the clinical skills necessary for practising ART. During the follow-up period, practitioners in these pilot clinics used the ART approach to restore teeth and extracted teeth that were beyond repair. Reports from supervisory visits and follow-up meetings with practitioners strongly indicated that ART could contribute substantially to reducing the number of extractions in Tanzania. This indicated that the Tanzanian population would benefit if the Basic Package of Oral Care (BPOC) were adopted.

In 2002, the WHO Collaborating Centre in Nijmegen published an oral health-care concept aimed at guiding oral health-care policy-makers in the organizing of basic oral care for use in communities worldwide. This concept is governed by

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evidence-based oral health activities and comprises the following elements: Urgent Oral Treatment (OUT), Affordable Fluoride-containing Toothpaste (AFT), and Atraumatic Restorative Treatment (ART) [10].

OUT alleviates toothache through extraction of badly decayed teeth. Furthermore, emergency care related to accidents and severe pathology is contained in this aspect of BPOC. ART deals with toothache in teeth that can be saved. Through use of glass ionomers to seal caries-prone tooth surfaces, ART also has a preventive aspect. Preventive maintenance of the dentition is taken care of through cleaning tooth surfaces with a brush and fluoride-containing toothpaste (AFT). This package cannot be used in isolation. It is recommended that it be introduced to the community in conjunction with educational and promotional activities. As the provision of oral care and maintenance of oral health through BPOC can be offered to communities at relatively low cost, the possibility that BPOC could make a difference in Tanzania was considered to be high.

When the idea was conceived, pilot clinics implemented the two components of BPOC: OUT by tooth extraction and restoration of decayed teeth by ART. It was not clearly known whether the third component of BPOC, AFT, was carried out as recommended. Studies that had been conducted on the oral hygiene practices of Tanzanians indicated that the majority of the population cleaned their teeth at least once a day [11–14]. There were differences in the cleaning agents used. Some used toothpaste regularly, some sporadically. Some used water only, and others, charcoal, ash, or salt. Two local factories manufacturing toothpaste claimed that their toothpaste contained adequate fluoride for dental caries prevention, but no tests had been done to prove these claims.

For fluoridated toothpaste to be used as a community preventive measure for controlling dental caries in Tanzania, the majority of the population have to clean their teeth with fluoride- containing toothpaste on a regular basis. Moreover, the toothpaste must contain fluoride concentrations of 1000–1500 ppm, which has been shown to be effective in preventing dental caries [15,16]. There was therefore a need to ascertain the proportion of people who used toothpaste on a regular basis, and to identify reasons for its irregular or non-use. There was also a need to ascertain the bioavailability of fluoride in toothpaste manufactured in Tanzania because not all toothpastes claiming to contain fluoride actually have it [17]. Furthermore, as information on the affordability of fluoride-containing toothpaste was lacking, the public needed to be interviewed with respect to cost, level of affordability, and use of fluoride-containing toothpaste. This information could prove useful in discussions with the toothpaste manufacturers in the country about increased use of fluoride-containing toothpaste. The aim of this study was to determine toothpaste use and the availability of fluoride in toothpaste manufactured in Tanzania in the context of implementing BPOC in that country.

Material and methods

Subjects and sampling procedures for questionnaire data

A pre-tested questionnaire in the Kiswahili language was used to collect data on toothbrushing habits and to assess perceptions regarding the importance of brushing the teeth with toothpaste and its cost. Patients aged 15 years and above, who attended 5 pilot dental clinics in 2 cities (urban) and 8 pilot clinics in districts (rural), participated in the study. Because the resident dentist was unavailable during the study period, data from 3 of the 16 pilot dental clinics could not be collected. To reduce the possibility of one patient filling in the questionnaire twice, the study period was limited to 2 weeks in June 2007. In addition, patients were asked not to fill in the questionnaire if they had completed the same questionnaire within the 2-week study period. Furthermore, the patients were informed that if any of them could not read or write, they were to seek the assistance of the dental worker. In Tanzania, most patients attend dental clinics for the relief of pain. The questionnaires were distributed in numbers corresponding to the known 2-weekly clinic patient load. A total of 1090 questionnaires were distributed to all 13 pilot clinics. The expectation was that if all questionnaires were filled in the resulting number of respondents would provide an adequate estimate regarding brushing habits and perceptions about the importance and cost of toothpaste in pilot clinic catchment areas.

Ethical clearance and procedures for obtaining informed consent

Written approval for the study was obtained from the Ethics Committee of the Muhimbili University College of Health Sciences through a letter with reference number MU/RP/AEC/VOL.II/130. The questionnaires were distributed to patients in clinic waiting rooms. Each had an attached message informing patients about the aim of the study, stating that filling/not filling in the questionnaire would in no way influence the treatment, and requesting that the questionnaire be completed. The practitioners were also directed to inform the patients about the aim of the questionnaire and to reassure them that filling/not filling in the questionnaire would in no way influence the treatment. Having read the attached message and been given explanations by the dentist was considered enough evidence of

consent from the patients who participated in this study. At the end of the study period, there were no documented reports of refusals.

Fluoride toothpaste samples

Locally manufactured toothpaste with different dates of expiry from two factories claiming to produce fluoridated toothpaste was collected from shops in Dar es Salaam, Tanzania. One factory manufactured two brands (triple action and herbal), the other factory only one. The aim of obtaining toothpaste with different expiry dates was so that the possible effect of shelf-life on the bioavailability of fluoride in toothpaste could be taken into consideration [18]. The price of each size and brand of toothpaste was recorded.

Construction of variables for statistical analysis

All questionnaire data were computed using Microsoft Excel software. After checking for accuracy, the data were transferred to SAS software (SAS Institute, Cary, N.C., USA) for statistical analysis. The independent variables studied were residence, gender, age, and level of education. Residence was categorized into 'rural' for the data collected from district dental clinics, and 'urban' for municipal dental clinics. Data regarding age in years were divided into 4 age group categories, i.e. 15–20 years, 21–30 years, 31–50 years, and 51+ years, and later dichotomized into young respondents (15–30 years) and older respondents (31+ years). Data for level of education were categorized as: primary education and below, secondary education and college, and higher education. These were later dichotomized into less educated (primary and lower) and educated (secondary and higher).

The dependent variables used in the analysis were: *"Do you brush your teeth?", "Do you use toothpaste?", "Why do you not use toothpaste?", "How often did you use toothpaste during the last 7 days?", "How important is brushing with toothpaste for you?", "Which toothpaste brand do you frequently use?"* and *"Opinion on the cost"*. Possible responses to *"Do you brush your teeth?"* and *"Do you use toothpaste?"* were "yes" or "no". *"Why do you not use toothpaste?"* was an open-ended question, the answers to which were categorized into "financial" and "not important". *"How often did you use toothpaste during the last 7 days?"* offered six options ranging from "never used" to "used twice daily". Those ranging from "never used" to "used not all days" were later grouped as irregular users, and those who used once or twice daily for all 7 days were classified as regular users. *"How important is brushing with toothpaste?"* had three optional responses: "very important", "important", "not important", which were later dichotomized into "not important" and "important" (important+very important). *"Toothpaste brand frequently used?"* was an open-ended question. Respondents were required to name the toothpaste brands commonly used and the responses were categorized as local brands and imported brands. *"Opinion on the cost of toothpaste?"* offered four options (very expensive, expensive, normal price, cheap), which were later dichotomized as "expensive" ("very expensive"+ "expensive") and "normal price" ("normal price"+ "cheap").

Statistical analysis

Cross-tabulations between residence and the other independent variables, gender, age, and level of education, were generated and the chi-square test was performed to identify any associations. Frequency distributions of respondents over the dependent variables studied were then generated. The chi-square test was applied to test for differences between independent and dependent variables. Residence, age, and level of education had significant associations with one or more dependent variables and were entered into a logistic regression model for each dependent variable for identification of their relative influence on these variables.

Laboratory analysis for toothpaste samples

The toothpaste samples were analyzed at the laboratory of the Dental School in Amsterdam, The Netherlands. In all toothpaste samples, the fluoride concentration was measured using a gas liquid chromatographic method and a fluoride electrode, as described by van Loveren et al. [17], methods that have been shown to be reliable for analysis of fluoride in toothpaste [17,19]. Each sample was analyzed twice for reliability of the analysis. The duplicate measurement error was determined using the Dahlberg formula $\sqrt{\{\sigma(x_1-x_2)^2/2n\}}$, whereby x_1 and x_2 are the duplicate measurement values and n the number of samples.

Results

The demographic characteristics of the respondents are summarized in Table I. A total of 978 patients (427 M and 546 F) filled in the questionnaires; 5 respondents did not indicate their gender. Proportionately more educated respondents were from urban areas than from rural areas ($\chi^2 = 13.47$; $p < 0.0001$).

The distribution of respondents according to answers to specific questions relating to brushing the teeth and use of toothpaste is given in Table II. Most respondents reported that they brushed their teeth, and, of these, only 36/978 (3.7%) did not use toothpaste. Of the 36 who did not use toothpaste, 21 (58.3%) reported that this was for financial reasons. Of the 130 who used toothpaste less than once a day, 57.7% reported financial reasons for their irregular

Table I. Percent (%) distribution of respondents by residence and gender, age, and level of education.

	Gender		Age groups		Level of education	
Residence	Male %	Female %	Young %	Older %	Less educated %	Educated %
Rural	47.7	52.3	56.2	43.8	69.3[a]	30.7[c]
Urban	42.3	57.7	57.7	42.3	56.6[b]	43.4[d]

Chi-square ab, cd $= p < 0.0001$.

use. Of the 934 respondents who used toothpaste, 86.7% used it once or twice daily. Only 5.3% of all respondents perceived brushing with toothpaste as not important. Regarding the cost of toothpaste, 34.8% perceived the toothpaste they used as expensive.

The logistic regression odds ratios indicating the relationship between residence, age, level of education and brushing habits, perceived importance, and cost of toothpaste are summarized in Table III. Proportionately more younger respondents than older ones reported that they brushed their teeth ($p < 0.05$), used toothpaste once or twice daily ($p < 0.0001$), perceived brushing with toothpaste to be important ($p < 0.0001$), and considered the cost of toothpaste to be cheap or normal ($p < 0.05$). Proportionately more urban respondents than rural respondents reported that they used toothpaste to brush their teeth ($p < 0.0001$) and perceived brushing their teeth with toothpaste to be important ($p < 0.01$). On the other hand, rural respondents perceived the cost of toothpaste as cheap or normal, in contrast to the opinion of urban residents ($p < 0.01$).

Table II. Distribution of respondents by responses to specific questions related to brushing the teeth and use of toothpaste.

Question	Percent
Do you brush your teeth? ($n = 978$)	
• Yes	99.2
• No	0.8
Do you use toothpaste? ($n = 970$)	
• Yes	86.3
• No	3.7
What were your reasons for not using toothpaste? ($n = 36$)	
• Financial	58.3
• Importance unknown	41.7
How often did you use toothpaste in the past 7 days? ($n = 934$)	
• Regularly once/twice a day	86.7
• Irregularly not every week to 3 days/week	13.3
What were your reasons for irregular use of toothpaste? ($n = 130$)	
• Financial	57.7
• Other	42.3
How important is brushing with toothpaste? ($n = 961$)	
• Important	94.7
• Not important	5.3
Which toothpaste brand do you commonly use? ($n = 936$)	
• Locally manufactured	79.0
• Imported	21.0
What is your perceived cost of a tube of toothpaste? ($n = 937$)	
• Normal priced	65.2
• Expensive	34.8

The total and free fluoride ions in toothpaste produced in Tanzania are given in Table IV. The measurement error was 6 ppm. Five of the eight toothpaste samples tested had labels indicating calcium abrasives of unknown compounds. Three samples had no label listing abrasive compounds. Although all factories claimed to produce toothpaste with fluoride for prevention of dental caries, none had free fluoride ions at the recommended concentration. The concentration of free fluoride in the toothpastes tested ranged from 66 to 384 ppm and prices varied from 0.35 to 1.20 euros per 100 gm.

Discussion

The data were collected from patients who attended 8 district and 5 municipal clinics participating in the pilot study for introduction of the ART approach in Tanzania. Although the data did not come from a random sample of the Tanzanian population, the findings from this study can be extrapolated to the Tanzanian population. This is because the living conditions and accessibility in most districts in Tanzania are similar. Likewise, the five municipal clinics were in Dar es Salaam and Tanga, cities which represent the urban features in Tanzania fairly well.

The fact that there were more educated respondents in urban than in rural clinics is obvious. Educated people tend to be concentrated in urban areas, where their employment opportunities are greater than in rural areas. In the current study, 99.2% reported brushing their teeth, and, of these, 86.7% brushed with toothpaste at least once daily. These findings confirmed the established fact that most of the population in Tanzania brush their teeth at least once a day [11–14]. The proportion of respondents who reported using toothpaste in the present study is similar to that reported in young mothers in Dar es Salaam, Tanzania [14] and among school children, parents, and school teachers in Beijing, China [20]. These findings indicate that fluoridated toothpaste can be used in this pilot area population as a preventive measure for controlling dental caries.

Although a third of respondents perceived the cost of toothpaste as expensive, only 75 of the 934 respondents who used toothpaste reported that

Table III. Logistic regression odds ratios (95% CI) for dependent and independent variables listed.

	Independent variable[$]		
Dependent variable[#]	Residence *urban*/rural	Age *older*/younger	Level of education *educated*/less educated
Do you brush your teeth?			
Yes	1.43 (0.34–6.05)	0.10 (0.01–0.85)*	NE
No			
Do you use toothpaste?			
Yes	5.06 (2.47–10.35)***	0.36 (0.18–0.75)**	NE
No			
Why not toothpaste?			
Financial	4.00 (0.91–17.54)	0.67 (0.15–3.03)	NE
Not important			
How often toothpaste?			
Regular users	1.14 (0.75–1.73)	0.36 (0.24–0.53)***	1.84 (1.22–2.80)**
Irregular users			
Importance of toothpaste?			
Important	2.57 (1.43–4.63)**	0.31 (0.17–0.58)***	2.00 (0.99–4.00)
Not important			
Cost of toothpaste?			
Normal priced	0.66 (0.48–0.90)**	0.73 (0.55–0.96)*	0.91 (0.69–1.20)
Expensive			

$ category in italics = reference category.
# category in italics = outcome of interest.
*$p < 0.05$; **$p < 0.01$; ***$p < 0.0001$.
NE = not entered in the model equation.

they used it less than once daily for financial reasons. This indicated that cost of toothpaste was not a hindrance to routine use of toothpaste among most respondents. Nevertheless, given the importance of toothpaste in oral health, there is a need for the government to reduce taxation on toothpaste so that manufacturers can lower the prices of their products, thus increasing the percentage of people using fluoridated toothpaste.

Urban residents were five times more likely to use toothpaste than were rural residents. Urban residents were also twice as likely to perceive brushing with toothpaste to be important as rural residents were. These findings indicate that urban residents were better informed than rural residents about the importance of brushing with toothpaste, and implies that encouragement is needed to raise toothpaste use in rural areas. The manufacturers of toothpaste need to be advised on the possibilities of expanding their market in rural areas, where most of the population live. The advocacy is likely to raise use of toothpaste in the rural population because, in this study, more rural than urban respondents perceived the cost of toothpaste as normal. These findings were similar to those reported among urban and rural secondary school students in Morogoro, Tanzania [21], among rural and urban people in Burkina Faso [22], and in China [23].

Younger respondents in the present study were more likely than older respondents to brush their teeth, use toothpaste, brush with toothpaste more regularly, perceive use of toothpaste as important, and regard the price as normal. This may represent a secular trend in society towards improved oral hygiene practices that gives hope for better oral health in the future. In the present study, educated respondents were more likely to brush their teeth with toothpaste than less educated respondents were, perhaps indicating that education improves oral hygiene habits in the population. These findings

Table IV. Total and free fluoride concentration in toothpaste manufactured in Tanzania.

Type of toothpaste	Expiry date (m/y)	Calcium abrasive	Fluoride on label	Calculated from label in ppm F	Total ppmF in analysis	Free ppm F in analysis	Price (€) /100gm (July 2007)
Whitedent Three in One (? gm)	03/2008	No	SMFP 0.76%	1000	339	384	–
Whitedent Herbal Stripe, 110 gm	12/2009	No	SMFP 0.76%	1000	292	333	€ 0.54
Whitedent Herbal Stripe, 70 gm	06/2010	No	SMFP 0.76%	1000	289	332	€ 0.67
Whitedent Triple Action, 15 gm	11/2009	Yes	SMFP 0.76%	1000	416	111	€ 1.20
Whitedent Triple Action, 25 gm	07/2010	Yes	SMFP 0.76%	1000	419	199	€ 0.60
Aha 24 hours protection, 100 gm	07/2007	Yes	Not indicated	N/A	482	66	€ 0.59
Aha 24 hours protection, 200 gm	12/2008	Yes	Not indicated	N/A	1029	198	€ 0.35
Aha 24 hours protection, 80 gm	02/2009	Yes	Not indicated	N/A	904	158	€ 0.51

are similar to those reported among Chinese [24] and Danish adults [25].

Fluoride in toothpaste samples

The free fluoride concentration found in toothpaste manufactured in Tanzania was below the standard level of 650–850 ppm [18]. The highest recorded free F ions concentration was 384 ppm. Meta-analysis studies and systematic reviews reveal consistent proof that toothpastes with a total fluoride concentration of 1000–1500 ppm are more effective than those with a concentration below 500 ppm [15,16,26,27]. Toothpaste manufacturers in Tanzania need to adhere to the proven concentrations of fluoride in toothpaste if consumers are to gain the benefit of fluoride in caries prevention. All toothpaste brands that had a calcium compound as abrasive had a consistently low free fluoride concentration, i.e. in one tube as low as 66 ppmF. This was the case despite the fact that some toothpastes had a total fluoride concentration of 1029 ppm. There is a need for the Tanzania Dental Association, Ministry of Health and Food and Drug Authority of Tanzania to discuss this issue with toothpaste manufacturers in Tanzania to ensure improvement in the bioavailability of fluoride in toothpastes produced in the country. The low free fluoride concentration found in the samples of toothpaste manufactured in Tanzania is similar to what has been reported in other non-established market-economy countries [17].

At the planning stage of the current study, it was anticipated that newly manufactured toothpaste samples would have higher concentrations of free fluorides than the toothpaste samples close to the expiry date. However, concentration of the free fluoride did not vary with the expiry dates of the toothpastes. This shows the need to repeat the analysis using a larger sample of toothpastes, and these perhaps to be analysed in more than one laboratory. Furthermore, the labeling on toothpastes was incomplete in all the samples analyzed. For example, the type of abrasive compound was not always indicated, and labels listing calcium abrasives did not give the name of the calcium compound used. Since the bioavailability of fluoride in toothpaste is influenced by the type of calcium compounds, there is a need for manufacturers to indicate on the label the fluoride-containing fluoride and the compound for the abrasive used.

Conclusions and recommendations

The data in the present study indicate that the majority of the population use toothpaste on a regular basis. A third of respondents perceive the price of toothpaste as expensive. Toothpaste manufactured and sold in Tanzania has free fluoride concentrations below the recommended levels for prevention of dental caries. To have a well-functioning BPOC package, oral health planners have to take measures aimed at lowering the price of toothpaste. The Ministry of Health and the Tanzanian Dental Association should initiate dialogue with toothpaste manufacturers and dealers to ensure that the bioavailability of fluoride in imported and locally produced toothpastes is at the recommended levels. A comprehensive study should be undertaken of the fluoride concentration in toothpastes manufactured in Tanzania.

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