Oral Health Status of Adults in Rural Meru, Kenya

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Abstract

Objectives: This study aimed to assess the oral health status of adults in the rural Kithoka community of Meru, Kenya.

Methods: A cross-sectional study of 102 adults, aged 20-90, that consisted of an oral health survey and dental examination was performed. Clinical data on caries history was collected using the DMFT index. Data on gingival recession, gingival inflammation, and fluorosis were also collected.

Results: Fifty-two percent of the population studied was female and 48% were male. Having no access to professional dental services was reported by 31% of the population. Seventy-eight percent of the population reported owning a toothbrush, while 83% of those individuals brushed daily. The average DMFT of the population was 3.9. Total DMFT comprised 58% decayed, 41.7% missing, and only 0.3% filled teeth. Eighty-one percent reported history of oral pain and 48% reported having oral pain at the time of the survey. Ten percent of the population presented with no gingival inflammation, 75% had mild-moderate inflammation, and 15% had severe inflammation; reminiscent of the natural history of periodontal disease percentages reported for untreated populations. Forty-six percent presented with varying degrees of gingival recession. Fluorosis prevalence was 22%.

Conclusion: A high level of untreated dental caries, gingival inflammation, and oral pain was found in the adult population of this community. The poor dental health status of this community is further perpetuated by limited access to care, suggesting that there is a need for increased oral care and implementation of cost-effective preventive strategies in this community.

Key Words: *Oral health, Dental caries, Periodontal disease, Fluorosis, Pain, Kenyan adults*

Introduction

Meru is a town located in the central part of Kenya on the northeastern slopes of Mount Kenya. The greater municipal region has a population of approximately 240,900 residents located in a dispersed mixed forest and farm environment that is home to many small towns, farms, and rural villages [1]. The sociological breakdown of this area is quite diverse with the Bantu ethnic group composing the majority of the population. The economic breakdown of Meru is also diverse and consists of a mix between agriculture, trade, and commerce [1]. However, a comprehensive literature search revealed that very little is known about the oral health status of this population or the disparities that might exist in access to proper professional dental care [2].

Currently, it is estimated that 50% of Kenyans live below the poverty level. One-third of rural populations, such as in Meru, are estimated to live in absolute poverty and cannot meet daily food and material requirements from salary wages. The Department of Oral Health Services is currently the governing body in Kenya that develops and implements national oral health policies and goals. The dentist to population ratio is 1:378,000 in the public sector with only 20% of dentists practicing in rural areas such as Meru. The cost of dental materials contributes to a dramatic cost escalation of dental services in the private sector and prevents lower income populations from obtaining access to proper dental care [3]. Furthermore, very few studies have been conducted in rural Kenya to assess the prevalence of oral diseases, dental decay, and periodontal disease in adult populations [4]. Rather, most of the available evidence on oral disease and oral health disparities in Kenya has been conducted in urban centers such as Nairobi and only on school-age populations [3].

The social, economic, and dietary patterns are changing rapidly throughout Kenya. The effects of modernization and industrialization have led to increased access and consumption of refined sugars and snacks available in local Kenyan markets [5]. These changes in dietary habits stray away from traditional diets and could have a considerable impact on the prevalence of dental caries and periodontal disease. The effects of oral disease and pain should not be underestimated. Although dental decay is not commonly viewed as a life-threatening condition, it can cause considerable social disruption and affect economic productivity [6]. Moreover, oral disease can have a dramatic impact on an individual in Kenyan society by causing pain, discomfort, and functional limitations that have an effect on quality of life [6]. Oral health disease can also result in an immeasurable impact on economic productivity in terms of lost hours of work/school and individual cost from private dental treatment [6].

In 2002, Kenya formulated a national oral health policy to set strategic goals for improving oral health in the next decade. Among the measures that were adopted, the precedent to create a more integrated health care system that included treatment of oral disease as part of improving overall health, was arguably the most important [3]. Traditionally, the treatment of oral disease has been given a much lower priority in government

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funding of developing countries, and Kenya is no exception to this trend. As late as 2002, oral health spending accounted for only 0.0016% of the Kenyan Ministry of Health budget [3]. Additionally, very little funding or emphasis is placed on oral health education or disease prevention. A Kenyan rural community-based survey conducted in 2006 of 141 adults found that 43% did not know the causes of dental disease and only 0.8% mentioned using fluoridated toothpaste to prevent dental caries [7].

Therefore, a significant inquiry is needed to assess the oral health status and oral health disparities that exist within rural Kenyan populations. Although some previous studies have shown rates of oral disease to be lower in African populations than other emerging parts of the world, most of these studies did not take into consideration the rapid changes that are occurring in the living conditions across Kenyan society [2]. The incidence of dental caries is expected to be much greater than previously reported due to the growing consumption of refined sugars and inadequate or inappropriate exposure to fluoride sources [2]. Additionally, there is a lack of information regarding the oral health status of rural Kenyan populations, such as the community of Meru. Without this crucial information, it will be difficult to implement a national Kenyan oral health policy that seeks to make improvements in access, education, and preventive measures to enhance the future of oral health care.

Consequently, the goals of our research were to evaluate the oral health status and needs of the Meru community through the perspective of access to care, assessment of need, and current oral hygiene practices. The aim of this cross-sectional interview survey and oral exam was to reach out to rural and adult populations of this region to learn more about the prohibitive barriers that play a role in oral health disparities of lower socioeconomic status individuals. Our goal as investigators was to gain an unbiased perspective that could be used in the development of policies, programs, and interventional measures to improve the quality of life and oral health of this community.

Design and Methods

The data collection for this cross-sectional study of 102 adult subjects took place over the course of two years, 2012 and 2013, in the rural Kithoka community of Meru, Kenya. Data was collected using iSurvey technology via iPads and all participants signed informed consent forms prior to participating. This study was also approved by the University of Michigan Institutional Review Board for human research and by the comparable review board for human research at the Kenya Methodist University in Meru, Kenya. Thirteen trained examiners from the University of Michigan School of Dentistry, with the help of translators as needed, administered the oral survey. The survey included demographic information and questions relating to oral hygiene practices, toothbrush ownership, pain, and access to care. In addition, visual examinations were performed using tongue depressors and gauze with natural daylight and handheld flashlights as the primary sources of illumination. Clinical data on dental caries or DMFT scores, fluorosis, and periodontal disease (gingival inflammation and gingival recession) were collected.

Researchers recruited subjects by traveling household-to-household within the Kithoka community of Meru, Kenya. Examiners were trained prior to arriving in Kenya and in the field to detect caries, fluorosis, gingival inflammation, and gingival recession. Images of different types and severity of caries, fluorosis, gingival inflammation, and gingival recession were used to train the examiners. Only carious lesions that were clearly cavitated were counted in determining the D-component of the DMFT score.

The Decayed, Missing, Filled (DMFT) index, used for over 70 years, is the standard epidemiological measure for caries and was the scale used in this study of adult subjects. Periodontal/gingival recession from 1-2 mm was ranked as mild recession, 3-4mm was ranked as moderate recession, and >4mm was ranked as severe recession. A visual gingival inflammation score (GIS) was developed for this study to assess no inflammation (score=0), mild gingivitis (score=1, slight redness at gingival margin), moderate gingivitis (score=2, definite redness of the gingival margin and papillary gingiva) and severe gingivitis (score=3, inflammation extending to the attached gingiva, ulceration, significant swelling or spontaneous bleeding), that was a simplified version of the PMA index [8]. GIS was considered localized if ≤ 30% and generalized if >30% of facial gingival sites were affected. A fluorosis index, Dean's Fluorosis Index was used to assess very mild, mild, moderate, and severe fluorosis [9].

Water samples were collected from homes where participants had given consent to test their water. GPS coordinates were taken on a Garmin Forerunner 305 GPS receiver with accuracy within fifty feet at all sample sites. Samples were placed into sealed 2mL vials and transported back to the United States for analysis. Fluoride concentration was analyzed using an ion-specific electrode (Thermo Scientific Orion Cat #9609BNWP) after sample buffering with an equal volume of TISABII (Ricca Chemical Co. cat #8670-16). 0.5mL of the water sample was added to 0.5mL TISABII in 1.0mL capacity microtubes and stirred at 300 RPM. Room temperature on day of analysis was 24°C and slope of the electrode was 59.1.

Statistical Analysis Methods

Compiled data were processed and analyzed using the Statistical Package for the Social Sciences (SPSS) and Excel software. Descriptive statistical methods were used to provide the baseline numbers for toothbrush ownership and use, DMFT scores, fluorosis, oral pain, and periodontal disease. Descriptive statistics including frequencies and cross tabulations were also performed. Bivariate analysis methods were used to analyze the data to identify correlations and the statistical significance mainly between age and DMFT which resulted in no statistical significance. There was also no statistical significance in experiences of pain, inflammation, and recession between males and females. All statistical tests were 2-sided and statistical significance was considered at $P<0.05$. Statistical significance was determined using the Pearson Correlation Test. A linear regression model was constructed using DMFT as the dependent variable with a mean of 38.59 and a standard deviation of 14.08. In addition, an extensive exploration of analyses, including descriptive

analyses, linear regression, correlation, and means testing were conducted for the study variables.

Results

A total of 102 adults were surveyed during the study, including 53 females (52%) and 49 males (48%) (**Table 1A**). The age of adults surveyed ranged from 20-90 years old. The largest age group surveyed was 26-45 years old (**Table 1A**). Sixty-seven percent (68/102) of adults reported having access to professional dental care, while 31% (32/102) reported not having access to professional dental care (**Table 1B**). Two percent (2/102) reported having no need to visit the dentist (**Table 1B**).

Access to dental care was further assessed by evaluating barriers associated with cost and travel. Forty-five percent (46/102) of the respondents reported that it would not be difficult to travel to be seen by a dentist, whereas 55% (56/102) reported that it would be difficult (**Table 1C**). Thirty-one percent (32/102) reported that cost would not be a barrier to seeing a dentist, whereas 69% (70/102) reported that cost would be a barrier (**Table 1C**).

The socioeconomic status of the adults surveyed was also evaluated by assessing access to running water and the presence of electricity in their homes. Twenty-nine percent (30/102) of the participants reported having no access to running water, whereas 71% (72/102) reported having access (**Table 1D**). Seventy-three percent (74/102) of the participants reported not having electricity in their homes, whereas 27% (28/102) reported having electricity (**Table 1D**).

Toothbrush ownership and subsequent brushing habits among the population were evaluated in the survey. Across the surveyed population of adults, 78% (80/102) reported owning a toothbrush, whereas 22% (22/102) reported not owning one (**Table 2A**). Among those who reported owning a toothbrush, 16% (13/80) reported non-daily brushing, whereas 84% (67/80) reported daily brushing (**Table 2B**). Ninety-three percent (74/80) of adults who report owning a toothbrush also report using toothpaste while brushing their teeth (**Table 2C**). In addition to assessing toothbrush ownership, ownership of traditional chewing sticks was also evaluated with 70% (71/102) reporting owning a chewing stick (**Table 2A**).

The average decayed, missing, filled tooth score (DMFT) was 3.9 (**Table 3A**). Twenty percent (20/102) of the participants presented with a DMFT score of zero, 57% (58/102) presented with a DMFT score of 1-5, 16% (16/102) presented with a DMFT score of 6-10, 5% (5/102) presented with a DMFT score of 11-15, 1% (1/102) presented with a DMFT score of 16-19, and 2% (2/102) presented with a DMFT score of 20 or more (**Table 3A**). The average decayed, missing, filled tooth score (DMFT) varied by age and gender. The average DMFT score was 2.8 for the 18-25 year old age group, 2.6 for the 26-45 year old age group, 3.3 for the 46-65 year old age group, and 13.1 for the 66+ age group (**Table 3A**). The average DMFT score for females was 4.2 whereas the average DMFT score for males was 3.5 (**Table 3B**). The total DMFT comprised 58% decayed (231/398), 41.7% missing (166/398), and only 0.3% filled teeth (1/398) (**Table 3C**). The average number of missing teeth increased as age increased with third molars being excluded. The average number of missing teeth was 0.6 for the 18-25 year old age group, 0.5 for the 26-45 year old age group, 2.7 for the 46-65 year old age group and 8.8 for the 66+ age group (**Table 3D***)*.

Gingival inflammation and recession were evaluated during the oral exams. Ninety percent (92/102) of the participants displayed gingival inflammation to some extent, whereas 10% (10/102) displayed no gingival inflammation (**Table 4A**). Seventy-five percent (77/102) of the population presented with mild-moderate inflammation and 15%

A			
Age (yr)	**Male**	**Female**	**Total**
18-25	9	8	17 (16%)
26-45	27	30	57 (56%)
46-65	10	12	22 (22%)
66+	3	3	6 (6%)
Total	49 (48%)	53 (52%)	102

B		C			D		
Access to Care	Total	Cost Issue	Yes	70 (69%)	Running Water	Yes	72 (71%)
Yes	68 (67%)		No	32 (31%)		No	30 (29%)
No	32 (31%)	Travel Issue	Yes	56 (55%)	Electricity	Yes	28 (27%)
No Need	2 (2%)		No	46 (45%)		No	74 (73%)

Table 1. *(A) Age and Gender; (B) Participant Reported Access to Care; (C) Participant Reported Barriers to Care; (D) Relative Socioeconomic Status.*

A		Age (yr)				Total
		18-25	**26-45**	**46-65**	**66+**	
Toothbrush Ownership	Yes	16	47	15	2	80 (78%)
	No	1	10	7	4	22 (22%)
Chewing Stick Ownership	Yes	8	43	16	4	71 (70%)
	No	9	14	6	2	31 (30%)

B			C	
Brushing Frequency	**Non-Daily Brushing**	13 (16%)	**Toothpaste Use**	**Total**
			Yes	74 (93%)
	Daily Brushing	67 (84%)	No	6 (7%)
Total		80 (100%)	Total	80 (100%)

Table 2. *(A) Toothbrush and Chewing Stick Ownership by Age; (B) Brushing Frequency of Toothbrush Owners; (C) Toothpaste Use of Toothbrush Owners.*

(15/102) presented with severe inflammation (**Table 4A**). Gingival inflammation generally presented more frequently as age increased. Eighty-two percent (14/17) of participants between the ages of 18 and 25 presented with gingival inflammation, whereas 100% (6/6) of the participants 66 years and older presented with gingival inflammation (**Table 4A**). The age ranges of 26-45 and 46-65 years both had 91% of participants present with gingival inflammation (52/57 and 20/22, respectively) (**Table 4A**). Evaluation of gingival recession showed that 46% (47/102) of participants presented with varying degrees of recession, whereas 54% (56/102) presented with no recession (**Table 4B**). Twenty-three percent (23/102) of the population presented with mild gingival recession, 13% (13/102) presented with moderate gingival recession, and 10% (11/102) presented with severe gingival recession (**Table 4B**). The presence of gingival recession increased with age. Twenty-four percent (4/13) of 18-25 year olds presented with recession, 39% (22/57) of 26-45 year olds presented with recession, 68% (15/22) of 46-65 year olds presented with recession, and 100% (6/6) 66 year old and older adults presented with gingival recession (**Table 4B**).

Fluorosis was present within this population. Twenty-two percent (22/102) of the population presented with varying degrees of fluorosis, whereas 78% (80/102) presented with no signs of fluorosis (**Table 5A**). Eleven percent (11/102) of the adults exhibited very mild fluorosis with less than 25% of the tooth surface affected and around 1-2mm of white opacity at the tips of the cusps of bicuspids/second molars (**Table 5A**). Eight percent (8/102) of the adults exhibited mild fluorosis with less than 50% of the tooth surface affected, while 3% (3/102) of the adult population exhibited moderate fluorosis (100% of the tooth surface affected, with possible brown staining) (**Table 5A**). Severe fluorosis was not found within the population. The 26-45 year old group had the largest number of participants that presented with fluorosis (**Table 5A**).

Water samples were taken at seventeen locations in order for an analysis of fluoride concentration to be conducted. The average fluoride concentration between these seventeen sites was 0.12 parts per million (ppm) and fluoride concentrations ranged between 0.01ppm and 0.17ppm (**Table 5B***)*.

Pain history and current pain levels were recorded for the adult population as well. Nineteen percent (19/102) of the respondents reported never having any dental pain, whereas 81% (83/102) of the respondents reported having dental pain at some time point during their lives (**Table 6A**).

Of those that reported pain, 33% (34/102) reported experiencing oral pain at some point in their lives, but not at

A

DMFT	Age (yr)				Total
	18-25	26-45	46-65	66+	
0	4	13	3	0	20 (20%)
1-5	11	35	11	1	58 (57%)
6-10	2	8	4	2	16 (15%)
11-15	0	1	3	1	5 (5%)
16-19	0	0	1	2	1 (1%)
20+	0	0	0	2	2 (2%)
Total	17 (16%)	57 (56%)	22 (21%)	6 (6%)	102 (100%)
Average	2.8	2.6	3.3	13.1	3.9

B

DMFT	Gender	
	Male	Female
0	15	5
1-5	25	33
6-10	6	10
11-15	1	4
16-19	0	1
20+	2	0
Total	49 (48%)	53 (52%)
Average	3.5	4.2

C

DMFT Component		
	Decayed	231 (58.0%)
	Missing	166 (41.7%)
	Filled	1 (0.3%)
	Total DMFT	398

D

Number of Missing Teeth	Age (yr)				Total
	18-25	26-45	46-65	66+	
0	12	40	7	0	59 (58%)
Few (1-3)	4	16	11	3	34 (33%)
Many (4+)	1	1	4	3	9 (9%)
Total	17	57	22	6	102
Average	0.58	0.49	2.71	8.83	1.47

Table 3. *(A) DMFT by Age; (B) DMFT by Gender; (C) Total DMFT Component Breakdown; (D) Number of Missing Teeth by Age.*

A

Inflammation Severity	Age (yr)				Total
	18-25	26-45	46-65	66+	
None	3	5	2	0	10 (10%)
Mild/Moderate	14	48	11	4	77 (75%)
Severe	0	4	9	2	15 (15%)
Total Participants	17	57	22	6	102
Total Participants with Inflammation	14 (82%)	52 (91%)	20 (91%)	6 (100%)	92 (90%)

B

Recession Severity	Age (yr)				Total
	18-25	26-45	46-65	66+	
None	13	35	7	0	59 (58%)
Mild	4	16	2	1	34 (33%)
Moderate	0	5	6	2	9 (9%)
Severe	0	1	7	3	11 (10%)
Total Participants	17	57	22	6	102
Total Participants with Recession	4 (24%)	22 (39%)	15 (68%)	6 (100%)	47 (46%)

Table 4. *(A) Gingival Inflammation by Age; (B) Gingival Recession by Age.*

the time of the survey, and 48% (49/102) reported currently being in dental pain at the time of the survey (**Table 6A**). In regards to gender, although not statistically significant, 68% of females (36/53) reported currently having dental pain at the time of the survey versus 27% of males (13/49). Nine percent of females (5/53) and 29% of males (14/49) reported never having any dental pain. In regards to toothbrush ownership, of those that had a history of oral pain or were currently experiencing oral pain at the time of the survey, 100% (22/22) did not own a toothbrush, whereas, 76% (61/80) owned a toothbrush (**Table 6B**). Of those who owned a toothbrush and had a history of oral pain, 78% reported daily brushing, whereas 69% reported non-daily brushing (**Table 6B**). As DMFT increased, so did the percentage of participants with a history of oral pain. Forty-five percent of participants that had a DMFT score of zero (9/20) reported having a history of oral pain or were currently in pain at the time of the survey (**Table 6C**).

Eighty-six percent of participants that had a DMFT score of 1-5 (50/58) reported having a history of oral pain or were currently in pain at the time of the survey. One-hundred percent of participants with a DMFT score of 6-10, 11-15, 16-19, and 20 or more (24/24) reported having a history of oral pain or were currently in pain at the time of the survey (**Table 6C**). Seventy-eight percent of the population that had no recession (43/55), 73% of the population that had mild recession (17/23), 100% of the population that had moderate recession (13/13), and 91% of the population that had severe recession (10/11) had a history of oral pain or were currently in pain at the time of the survey (**Table 6D**). Eighty percent of the population that had no signs of gingival inflammation (8/10), 79% of the population that had mild-moderate gingival inflammation (61/77), and 93% of the population that had severe gingival inflammation (14/15) had a history of oral pain or were currently in pain at the time of the survey (**Table 6E**).

When examining several disease and oral parameters in combination, the data reveal that negative oral conditions typically occur concurrently. Zero percent of the adults presented with a DMFT score of zero, no pain history, no gingival inflammation, and no gingival recession. Twenty-three percent (23/102) of adults presented with all three parameters of oral disease coincidently, including a DMFT score of 1 or greater, pain, and gingival inflammation, whereas 28% (29/102) of adults exhibited a DMFT score of 1 or greater, pain, gingival inflammation, and gingival recession.

Discussion

This is one of the first studies to explore the overall dental health of an adult Kenyan population from a rural setting. The results of the cross-sectional interview survey showed that there are significant oral health issues within the rural population of Meru. Many studies have been completed in Kenya to assess the prevalence of oral diseases, dental decay, and periodontal disease in adult populations, but very few have explored these multiple aspects concurrently. As stated in a study completed by Baelum et al [10], Africa cannot be considered a coherent and uniform continent, as huge

A

Fluorosis Severity	Age (yr)				Total
	18-25	26-45	46-65	66+	
None	14	40	21	5	80 (78%)
Very Mild	1	8	1	1	11 (11%)
Mild	1	7	0	0	8 (8%)
Moderate	1	2	0	0	3 (3%)
Severe	0	0	0	0	0 (0%)
Total Participants	17	57	22	6	102
Total Participants with Fluorosis	3 (18%)	17 (30%)	1 (5%)	1 (17%)	22 (22%)

B

Sample Number	GPS Coordinates	Fluoride Concentration (ppm)
1	N 0 05.872, E 37 40.160	0.01
2	N 0 06.395, E 37 39.835	0.09
3	N 0 06.619, E 37 39.419	0.09
4	N 0 06.581, E 37 39.523	0.09
5	N 0 06.339, E 37 39.832	0.11
6	N 0 05.994, E 37 39.368	0.12
7	N 0 05.550, E 37 39.486	0.12
8	N 0 05.590, E 37 39.587	0.12
9	N 0 07.364, E 37 39.948	0.12
10	N 0 07.535, E 37 39.948	0.12
11	N 0 06.841, E 37 40.108	0.13
12	N 0 05.905, E 37 40.158	0.14
13	N 0 05.951, E 37 40.223	0.14
14	N 0 06.123, E 37 39.851	0.14
15	N 0 05.575, E 37 39.552	0.15
16	N 0 06.372, E 37 39.937	0.15
17	N 0 05.810, E 37 39.870	0.17
Average Fluoride Concentration		0.12

Table 5. *(A) Fluorosis Severity by Age; (B) Water Sample Fluoride Concentration.*

A		Age				Total
		18-25	26-45	46-65	66+	
Pain History	Never	3	12	4	0	19 (19%)
	Pain in Past	7	19	7	1	34 (33%)
	Current Pain	7	26	11	5	49 (48%)
Total Participants		17	57	22	6	102
Total Participants with Pain		14 (82%)	45 (79%)	18 (81%)	6 (100%)	83 (81%)

B		Pain History			Total Participants	Total Participants with Pain
		Never	Pain in Past	Current Pain		
Toothbrush Ownership	Yes	19	24	37	80	61 (76%)
	No	0	10	12	22	22 (100%)
Brushing Frequency of Toothbrush Owners	Daily Brushing	15	21	31	67	52 (78%)
	Non-Daily Brushing	4	3	6	13	9 (69%)

C		DMFT						Total
		0	1-5	6-10	11-15	16-19	20+	
Pain History	Never	11	8	0	0	0	0	19 (19%)
	Pain in Past	6	21	6	0	0	1	34 (33%)
	Current Pain	3	29	10	5	1	1	49 (48%)
Total Participants		20	58	16	5	1	2	102
Total Participants with Pain		9 (45%)	50 (86%)	16 (100%)	5 (100%)	1 (100%)	2 (100%)	83 (81%)

D		Recession Severity				Total
		None	Mild	Moderate	Severe	
Pain History	Never	12	6	0	1	19 (19%)
	Pain in Past	18	7	6	3	34 (33%)
	Current Pain	25	10	7	7	49 (48%)
Total Participants		55	23	13	11	102
Total Participants with Pain		43 (78%)	17 (73%)	13 (100%)	10 (91%)	83 (81%)

E		Inflammation Severity			Total
		None	Mild/Moderate	Severe	
Pain History	Never	2	16	1	19 (19%)
	Pain in Past	5	25	4	34 (33%)
	Current Pain	3	36	10	49 (48%)
Total Participants		10	77	15	102
Total Participants with Pain		8 (80%)	61 (79%)	14 (93%)	83 (81%)

Table 6. *(A) Pain History by Age; (B) Pain History by Toothbrush Ownership and Brushing Frequency; (C) Pain History by DMFT; (D) Pain History by Recession Severity; (E) Pain History by Inflammation Severity.*

differences may be observed between population groups. Due to this observation, studies done in specific geographical regions cannot always be extrapolated to other regions, even if they are in the same African country. The oral diseases of each community need to be assessed individually. According to the literature, very few studies have been completed that explore oral health within adult populations located in rural Kenyan regions. Rather, most of the available evidence on oral disease and oral health disparities in Kenya has been conducted in urban centers, such as Nairobi [3]. The purpose of this study was to evaluate the need for oral care and evaluate the need for additional studies in rural regions of Kenya and similar rural regions in other African countries. The study team also provided oral health education and oral hygiene instructions.

As previously noted, the dentist to population ratio in the public sector of Kenya is 1:378,000 with only 20% of dentists practicing in rural areas, such as Meru. The cost of dental materials contributes to a dramatic cost escalation of dental services in the private sector and prevents lower income populations from obtaining access to proper dental care [3]. Rural areas, such as Meru, are severely affected by an overall lack of dental care. Our survey results indicate that not being able to afford adequate dental care and not being able to travel to a dental office are two primary barriers adults in this region encounter with access to professional dental care. In 2006, Thorpe also stated that in African countries, the main barriers to providing oral health care services were transportation and financial resources [11]. A study evaluating the oral health status of an elderly population in Nairobi in 2008 found that the major problem faced by the elderly was limited access to finances [12].

Periodontal health and brushing habits were also explored to gain a better perspective on the oral health status and needs of this population. Although a relatively high number of total respondents reported owning a toothbrush and brushing, a high percentage of individuals also reported pain and having current carious lesions. Inadequate removal of plaque due to a potential lack of oral health care knowledge and proper brushing techniques could be the underlying causes. In a study that evaluated oral health habits and periodontal health in a group of university students in Nairobi, Kenya, high levels of plaque were found although all of the participants reported brushing [13]. Similarly, a high percentage of participants in our study reported brushing while a high percentage of participants also presented with signs of caries and gingival inflammation. In a 1988 study conducted by Baelum et al, 1131 adults aged 15-65 years old were evaluated in the Machakos District in Kenya. Baelum et al found that oral hygiene was poor and that plaque was found on 75-95% of all tooth surfaces depending on age [14]. Older age groups were found to have a higher number of surfaces with visible plaque deposits [14]. Previous studies reported that an overwhelming

percentage of adults in rural Kenyan regions do not possess basic oral health knowledge. A Kenyan rural community-based survey conducted in 2006 on 141 adults found that 43% did not know the causes of dental disease and only 0.8% mentioned using fluoridated toothpaste to prevent dental caries [7]. Additionally, only 29.4% of the participants mentioned toothbrushing as a preventive measure for dental decay and gum decay [7]. Given these data for adults in rural Kenyan communities, it is probable that other similar populations in different rural Kenyan communities do not have an adequate level of dental knowledge and toothbrushing techniques.

Severe dental malocclusion was noted in two participants and was not considered to be contributory to plaque retention leading to oral health problems in this population. Additionally, 19% (19/102) of the participants reported current tobacco use. Tobacco use has been proven to have negative effects on periodontal health and may have contributed to some of the oral health problems observed in this population.

During the oral health exams, the prevalence and severity of gingivitis and gingival recession were recorded. Nearly 90% (92/102) of the respondents that were examined in our study had some form of gingival inflammation present. A similar adult population study in the urban area of Nairobi, Kenya reported that 77.4% of their respondents presented with gingival inflammation [15]. It is interesting to note that the proportions of inflammatory disease severity within the adult population in our study are similar to those reported in the classic studies on the natural history of periodontal disease [16]. In our study's population, no inflammation was found in 10% of the adult respondents, a mild-moderate level of inflammation was found in 75%, and a severe level was found in 15% of the adult respondents. The classic studies on the natural history of periodontal disease noted that 8% of individuals present with rapid progression of periodontal disease, 81% have mild-moderate progression, and 11% have no progression [16]. The periodontal health of the current population was also measured by looking at the severity of gingival recession. In our study, 56% of adults were found to have recession. In 2002, Baelum et al found that gingival recession was present in 27.2-100% of adult populations in studies conducted in several African countries such as Tanzania (27.2%), Nigeria (57.5-60.4%), and Bissau (83-100%) [10]. The percentage of adults in our study with gingival recession fall within the range of these reported values.

As previously reported, endemic dental fluorosis has been a public health concern in many parts of Kenya as a result of the high percentage of fluoride in drinking water in the East African region [17]. A study conducted from 1979-1982 examined 34,287 Kenyan individuals and found a national prevalence level of dental fluorosis to be 32% with sub-locations in the Rift Valley being significantly higher [17]. Additionally, a study of 527 individuals from the Meru area found a dental fluorosis prevalence of 20.2% [17]. In our study, we found a dental fluorosis prevalence of 22% in the adult population. Although the dental fluorosis prevalence value in our study was lower than the national average, it is similar to the fluorosis prevalence value found in other studies for the Meru region. Interestingly, the average fluoride concentration for the home drinking water in the surveyed area in Meru was 0.12 ppm F^-. This value is much lower than the 0.7 ppm F^- utilized and recommended by many industrialized countries around the world [18]. Additionally, this value is much lower than most geographical regions of Kenya where fluoride ion concentrations above 1.0 ppm have been found in 61.4% of geographical regions, and fluoride ion concentrations above 5.0 ppm have been found in 19.5% of Kenyan geographical regions [19]. Another study that analyzed seven water samples from the Meru region have shown that one of those samples was within 0.0-0.4 ppm, three were within 0.5-1.0 ppm, two were within 1.1-3.0 ppm, and one was within 3.1-5 ppm [19]. Although no average water fluoride concentrations have been concluded for this region, all seventeen of our water samples fell between 0.01 and 0.19 ppm. Due to the lower fluoride ion concentration in the drinking water of this community, the dental fluorosis present in our population must be explained by a factor other than drinking water.

The DMFT survey conducted in our study found that there was a significant prevalence of unmet dental needs in the adult population in the Meru area. The survey showed that the average DMFT score was 3.9. Third molars were excluded from this survey due to their genetic variability and frequent absence. This mean DMFT of 3.9 for all ages in the adult population is high amongst other African countries [11]. A study conducted in Uganda with 396 adults aged 35-44 found the mean DMFT to be 3.4 [20]. In Tanzania, a study conducted on 5,532 adults found the DMFT for 20-29 year-olds to be 1.8, 3.8 for 50-59 year-olds, and 8.1 for participants older than 60 years old [21]. In the Tanzanian adult population studied, "missing" was the dominant component of the DMFT whereas "decayed" was the dominant component in our population. Because there is limited research that has been conducted on African adults in terms of caries rates and prevalence, drawing direct comparisons between studies is difficult due to regional variation in populations and contributing factors. Very few studies have been conducted in Kenya to determine the caries rates and prevalence of adults in rural settings as well. In a similar cross sectional study of 141 adult subjects in the El Wak community on the border of Kenya and Somalia, the mean DMFT was 3.4 for the surveyed adult population [7]. In the same study, 56.7% of all adult subjects were caries free [7]. In comparison, only 20% of the surveyed adult population in our study was determined to be caries free. This discrepancy in the number of caries free individuals, while having a similar overall adult average DMFT score, could be explained by adults presenting with fewer missing and filled teeth in the Meru region as compared to the El Wak region. In other words, individuals in the El Wak rural region presented with a higher number of missing and filled teeth relatively compared to the number of carious teeth. Another study conducted in Nairobi, Kenya on 289 elderly individuals, average age 60.6 years, found a mean DMFT of 7.17 [12]. Additionally, 19.7% of these respondents had no caries experience and only 1.9% of the DMFT components were comprised of filled teeth [12]. Interestingly, out of 398 teeth that were examined in the 102 individuals in our study, only one tooth (0.3%) was noted as having a restoration. This statistic indicates that there is a high level of unmet dental needs in the Meru region of Kenya, and

that there are a large number of individuals in the area that have active carious lesions.

The trends in dental decay in this population seem to follow the trends found in other adult populations with first and second molars being the most commonly affected teeth and mandibular incisors tending to be the most caries resistant [4]. Similar to other reported trends [15], the mean number of teeth with caries experience increased with age in the adult population of our study. While other similar studies present conflicting information regarding the difference in caries prevalence in males versus females in Kenyan communities [4,8], our study shows that the average DMFT is 3.5 for males and 4.2 for females. Interestingly, 68% (36/53) of the females and 27% (13/49) of the males in our study were experiencing oral pain at the time of the survey. Although not statistically significant, this indicates that women in our population generally presented with untreated oral conditions causing pain more often than males . In a study conducted by Manji et al of 1131 adults aged from 15-65 in a rural area of Kenya, it was found that more teeth were lost due to caries among women than among men [22]. Based on this data, the higher percentage of females experiencing pain at the time of the survey, as compared to males, is most likely attributable to females having more severe untreated carious teeth that should be extracted than males.

Previous studies have shown that people from Africa retain a large number of teeth despite overall poor oral health and they retain more teeth than similar age groups in European and North American populations [10]. Furthermore, dental caries is the primary etiology of tooth loss among adult African populations where there is minimal access to professional dental care [10,22]. In a Tanzanian adult population study, periodontal disease was only a minor cause of tooth loss in the studied population [23]. Also, a small percentage of the population accounted for the majority of periodontal disease despite overall very poor oral hygiene [23]. In a study conducted on university students in Nairobi, Kenya, the mean number of teeth present per participant was 27.6 teeth, excluding third molars [13]. Another study that examined 1,131 participants, aged 15 to 65, in the rural Northern Division of Machakos District, Kenya, reported that over 90% of the individuals had more than 16 functional teeth present up to the age of 65 [4]. Our data suggest similar findings in that the younger adult age group of 18-25 years old experiences very few missing teeth while as age increases, so do the overall number of missing teeth.

The data collected and evaluated in this study provide a good representation of the unmet need in the rural areas of Kenya. However, limitations exist. This study used a convenience sample of adults in the community versus a true randomized sample. Since only obviously cavitated lesions were recorded, the number of carious lesions could be underestimated. Due to a less than ideal examination environment (natural lighting with supplemental flashlights, no hand mirrors, and no dental instruments), the extent of oral diseases found in our study could be inaccurate and potentially underreported. Although these limitations exist, it is important to use this information in order to implement preventive programs and bring awareness to oral health care needs in rural areas of Kenya.

In summary, a high level of untreated dental caries, gingival inflammation, and oral pain was found in the adult population of the Kithoka region of Meru, Kenya. The poor dental health status of this community is further perpetuated by limited access to care, suggesting that there is a need for increased oral care and implementation of cost-effective preventive strategies in this community. Additional resources and national funding in Kenya should be directed toward programs that aim to improve the oral health of rural communities. Due to the high level of untreated oral problems in this adult population, sustainable programs should be created to help alleviate these unmet needs. Additionally, programs should be established to provide oral health education in rural primary and secondary schools to help decrease the number of future unmet oral health needs.

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