Oral Health Status of Children in Rural Schools in Kithoka, Kenya

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Abstract

Background: Oral health studies to address dental needs of children have been conducted in Nairobi, Kenya. However, limited data is available for the rural areas of Kenya. The aim of this study was to gather baseline oral health data on primary school children in the rural Kithoka community of Meru, Kenya.

Methods: A cross sectional dental examination and oral health survey of 583 children, aged 3-18 years, were performed. Decayed, missing, and filled primary/permanent teeth (dmft/DMFT) values were recorded. Gingival recession ranking, a gingival inflammation index, and a fluorosis index were also employed. Children were surveyed regarding dental visits, toothbrush ownership, and oral pain.

Results: The average dmft/DMFT score was 1.2, fluorosis prevalence was 29%, gingival disease prevalence was 75.1%, oral pain prevalence was 29%, and 72% of children had never been to a dentist.

Conclusions: DMFT scores for Kenyan children were almost exclusively comprised of decayed teeth. This finding probably reflects the low dentist-to-population ratio and the scarcity of dentists practicing in Kenyan rural areas. Gingival disease and pain prevalence in these children were high, exceeding those reported in developed countries. The findings reflect the oral health preventive and treatment needs for children in this Kenyan region.

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

Abbreviations: dmft/DMFT: Decayed, missing and filled primary/permanent teeth, SPSS: Statistical Package for the Social Sciences, HIV: human immunodeficiency virus, NUG- acute necrotizing gingivitis, TFI: Thylystrup Fejerskov Index, ppm: parts per million, WHO: World Health Organization

Introduction

Oral disease prevention, health promotion, and access to care are important aspects of oral health in a global setting. There are many social, economic, political and cultural features that affect the ability of developing countries to provide adequate health care for their people. Therefore, global health research, which includes the gathering of public health data, is important for attracting international and government attention and funding to address the specific needs of a particular developing region.

In Kenya, there are several factors that affect the country's ability to provide adequate oral health care for its people. Kenya's population is approximately 30 million with 5% of its population under the age of one, 20% under the age of five, and 50% under the age of fifteen [1]. About 33% of the rural population lives in absolute poverty, while 10% of the urban population lives in absolute poverty [1]. Compounding the issue of a large young population demographic in Kenya is the inadequate or poor oral health care services in the public institutions, cost escalation in the private sector, and lack of access to health services for an increasing section of the population. The dentist to population ratio of 1:378,000 in the public sector, is another issue that limits adequate oral care within the country. Only 20% of dentists are in rural areas compared to 80% in urban environments [1].

Several studies have been conducted in Kenya, especially in its capital city of Nairobi, to address the dental needs of children. However, many rural areas have not attracted the attention of researchers [2]. It is important to evaluate the oral health needs of children within rural settings of Kenya in order to evaluate potential oral health disparities that exist in those communities. Furthermore, given that endemic fluorosis has been a public health concern in many parts of Kenya as a result of the high fluoride content in drinking water and because of its impact on oral health, fluorosis prevalence and severity warrants investigation in these rural settings. Oral health data collected from rural settings could help inform the local school administration and government health agencies about the oral health needs of these communities, as well as provide new information on the oral health needs of children in an area that has not been extensively investigated. These public health data are useful measures of a community's overall well-being and are important to the future development of this populace and others similar to it.

Gichunge and Kithoka Primary Schools, the subject of the current study, are both located in the rural Kithoka area of Meru. Gichunge Primary School was established in 1977. Currently the school has 12 teachers and a total student population of 267 students in grades 1-8 [3]. Kithoka Primary

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School was established in 1965. It currently has 15 teachers and a student population of 446 students, including a nursery school and standards 1-8.

Each standard is composed of two classes. Both of these schools are public day schools that operate with very limited financial resources. At Gichunge Primary 7% of the student population is orphaned, 11% have lost their father, and 22% have lost their mother. At both schools the majority of parents, 92%, work as smallholder (subsistence) farmers. Their wages are not always consistent and different factors, such as weather and gas prices, can influence how much they are paid. If a student is living with just one parent it can be extremely difficult for them to provide balanced meals on a daily basis. Needless to say, with these limited resources, oral health education and care is very limited.

The purpose of the current study was to assess the oral health status of children within the rural Kithoka area of Meru, Kenya by investigating the prevalence of dental caries, fluorosis, periodontal disease, pain, and access to care.

Design and methods

The data collection for this study took place from 2012 to 2013, at two primary rural schools, Gichunge Primary and Kithoka Primary, in the Kithoka community of Meru, Kenya. Childrens' surveys were developed to determine demographic information and the dental needs of children within the rural community of Kithoka in Meru, Kenya.

Consent forms in the local language of Kimeru were distributed to parents to explain the intent of the research study and to obtain permission to collect data. The survey was administered in English by 13 calibrated examiners utilizing iSurvey technology via iPads and it included demographic information and questions relating to oral hygiene practices, toothbrush ownership, pain, and access to care. In addition, clinical data on dental caries or dmft/DMFT scores, fluorosis, and periodontal disease (gingival inflammation and gingival recession) was collected by trained examiners. Exam data were collected using a visual examination and natural light. Dental caries were denoted as positive when obvious cavitation was present. Images of different types and severity of caries, fluorosis, gingival inflammation, and gingival recession were used to calibrate examiners. Local school teachers assisted with English translation and organization when needed. This study was 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.

The Decayed, Missing, Filled (DMFT) index, used for over 70 years, is the standard epidemiological measure of caries and was the scale used in this study. Given that children surveyed in this study were in mixed dentition, the survey evaluated both primary (dmft) and permanent (DMFT) teeth, thus a dmft/DMFT index was the parameter measured. In addition, since missing teeth cannot be determined readily during mixed dentition stages, the survey primarily assessed decayed and filled teeth. Periodontal/gingival recession from 1-2 mm was ranked as mild recession, 3-4 mm was ranked as moderate recession, and >4 mm was ranked as severe recession. A gingival inflammation index, the Gingival Index was used to measure mild, moderate, and severe inflammation [4]. A fluorosis index, Dean's Fluorosis Index [5] was used to assess very mild, mild, moderate, and severe fluorosis.

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, the numbers of dental visits, dmft/DMFT scores, fluorosis, oral pain, and periodontal disease. Descriptive statistics such as frequencies and cross tabulations in SPSS identified the correlations between responses in the survey, such as the relationship between pain dmft/DMFT and between dmft/DMFT and gingival inflammation. Tableau 8.0 software and Excel were used to visualize the compiled survey data. 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 583 children were surveyed, including 290 females and 293 males (*Table 1A*). The largest group surveyed was the 13 year olds (47 females and 43 males). Four-hundred, twenty-two children (73%) indicated they had never seen a dentist (*Table 1B*). One-hundred, twenty-nine (22%) children said they had been to the dentist, while 32 (5%) could not recall. Three-hundred, fifty children (60%) indicated they owned a toothbrush while 201 (35%) did not. 32 (5%) children were unsure if they owned a toothbrush (*Table 1C*).

Two hundred sixty-seven (46%) children presented with active carious lesions (*Table 1D*). The average decayed, missing, filled tooth score (dmft/DMFT) was 1.2. The children with the highest dmft scores, included the 6-8 year olds (average 1.7 dmft), whereas the lowest DMFT scores were in the 9-11 year olds (average 0.84 DMFT). Males and females had similar dmf/DMFT scores, 1.15 and 1.26 respectively (*Table 1E*). Ninety-nine percent (694/701) of teeth with caries history had active carious lesions, while the remaining 1%

Table 1. *Number of Children Surveyed, Dental Visits, Toothbrush Ownership, and DMFT by Age and Gender Distribution. A. Table reporting the numbers of children surveyed in the study distributed by age and gender. B. Table reporting the number of children that reported whether or not they had a dental visit. C. Table depicting the number of children that reported whether or not they owned a toothbrush. D. Table reporting the numbers of children with different DMFT scores by age distribution. E. Table reporting the numbers of children with different DMFT scores by gender.*

A		Age																Total
		3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
Gender	Female	1	6	14	11	24	29	25	26	27	30	47	28	12	10			290 (50%)
	Male	1	12	19	27	22	29	24	24	17	25	43	27	14	5	3	1	293 (50%)

Children by Age and Gender

B		Dental Visit			Total
		No	Yes	Unsure	
Gender	Female	217	60	13	290 (50%)
	Male	205	69	19	293 (50%)
Total		422 (73%)	129 (22%)	32 (5%)	

Dental Visits by Gender

C		Toothbrush Ownership			Total
		No	Yes	Unsure	
Gender	Female	87	190	13	290 (50%)
	Male	114	160	19	293 (50%)
Total		201 (35%)	350 (60%)	32 (5%)	

Toothbrush Ownership by Gender

D		Age																Total
		3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
DMFT	0	1	13	13	16	17	21	23	29	32	34	58	35	13	8	3		316 (54%)
	1-2	1	4	14	14	11	22	20	15	9	15	20	7	8	4		1	165 (28%)
	3-5		1	5	6	11	12	5	5	3	5	9	7	3	2			74 (12.6%)
	6-8			1	2	5	3	1	1		1	3	6	2	1			26 (0.4%)
	9-10					2												2 (0.003%)
Average DMFT		1.1			1.7			0.84			1.03			1.02				1.2

DMFT by age

E		Gender		Total
		Female	Male	
DMFT	0	158	158	316 (54%)
	1-2	78	87	165 (38%)
	3-5	37	37	74 (12.6%)
	6-8	16	10	26 (0.4%)
	9-10	1	1	2 (0.003%)
Average DMFT		1.26	1.15	1.2

DMFT by Gender

were filled. 5 of the filled teeth were permanent teeth and two were deciduous teeth.

Fluorosis was present within this population (*Table 2*). One hundred and one (17%) children demonstrated very mild fluorosis with less than 25% of the tooth surface affected and around 1-2mm of white opacity at the tip of the cusps of bicuspids/second molars (*Table 2A*). Fifty-six (9.6%) children had mild fluorosis with less than 50% of the tooth surface affected, while 12 (2%) children presented with moderate fluorosis (100% of the tooth surface affected, with possible brown staining). Four-hundred, fourteen (71%) children displayed no fluorosis. Severe fluorosis was not found in the sample population. The age group with the most fluorosis involvement across all levels of fluorosis was the eight year olds. Fluorosis affected more females (90/290; 31%) than males (79/293; 27%) (*Table 2B*). Ninety (15%) children had both fluorosis and DMFT scores of 1 or greater (*Table 2C*).

Twenty-nine percent (167) of the children were experiencing oral pain at the time of examination (*Table 3A*). Seventy-three (13%) of those in pain were experiencing a mild level of pain, while moderate (8%) and severe (8%) pain were seen in 47 children in each category (*Table 3A*). The largest group having pain were the 8 year olds (25/58; 43%). More females (89/290; 31%) than males (78/293; 27%) were experiencing pain (*Table 3B*). Children experiencing no pain had a mean dmf/DMFT of 0.99 (*Table 3C*). Those experiencing mild pain had a dmf/DMFT score of 1.37, and those with moderate and severe pain each had a mean score of 2.02 dmf/DMFT. Thus, the children with the most pain had the highest dmft/DMFT scores.

Evaluation of periodontal inflammation showed that 360 children (62%) presented with mild gingivitis, 67 (11%) with moderate gingivitis, and 1 (.002%) with severe gingivitis, whereas 155 (27%) children had no evidence of periodontal inflammation (*Table 4A*). However, children of all ages exhibited periodontal inflammation. More males (221/293; 75%) than females (207/290; 71%) presented with periodontal inflammation (*Table 4B*).

Evaluation of gingival recession revealed that 565 (96%) children had no gingival recession (*Table 4C*). However, 13 (2%) children exhibited mild recession (1-2mm), 3 (.005%) children exhibited moderate recession, and 2 (.003%) children exhibited severe recession (>4mm). Children with recession were between 8-15 years of age. The children with the most recession were the 13-15 year olds. More males (12/301; 4%) than females (6/290; 2%) presented with gingival recession (*Table 4D*).

When examining several disease and oral parameters in combination, the data reveal that there is a subset of children that exhibit a higher level of overall disease and positive oral findings, since they exhibited several concurrent conditions. Ninety (15%) of the children had both dmft/DMFT scores of 1 or greater and coincident fluorosis ranging from very mild to moderate (*Table 2C*). Ninety-eight (18%) of the children

Table 2. *Fluorosis by Age, Gender, and DMFT Distribution. A. Table reporting the numbers of children with different levels of fluorosis severity by age distribution. B. Table reporting the numbers of children with different levels of fluorosis severity by gender. C. Table reporting the numbers of children with different levels of fluorosis severity by DMFT distribution.*

A		Age																Total
		3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
Fluorosis Severity	Normal	2	15	29	31	28	23	34	27	33	42	70	45	19	12	3	1	414 (71%)
	Very Mild		1	2	4	14	18	7	15	7	6	12	9	4	2			101 (17%)
	Mild		1	2	2	4	12	8	7	4	6	7	1	1	1			56 (9.6%)
	Moderate		1		1		5		1		1	1		2				12 (2%)

Fluorosis Severity by Age

B		Gender		Total
		Female	Male	
Fluorosis Severity	Normal	200	214	414 (71%)
	Very Mild	57	44	101 (17%)
	Mild	28	28	56 (10%)
	Moderate	5	7	12 (2%)

Fluorosis Severity by Gender

C		DMFT											Total
		0	1	2	3	4	5	6	7	8	9	10	
Fluorosis Severity	Normal	237	69	40	30	11	9	6	7	3	1	1	414 (71%)
	Very Mild	50	20	14	5	5		3	3	1			51 (9%)
	Mild	25	11	8	4	6	2						31 (5%)
	Moderate	4	1	2		1	1		3				8 (.01%)

Fluorosis Severity by DMFT

Table 3*. Pain Severity by Age, Gender, and DMFT Distribution. A. Table reporting the numbers of children with different levels of pain by age distribution. B. Table reporting the numbers of children with different levels of pain by gender. C. Table reporting the number of children with different levels of pain by DMFT distribution.*

A	Age																Total
	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
None	2	17	30	30	30	33	34	35	26	34	67	41	22	11	3	1	416 (71%)
Mild		1	2	5	10	11	8	10	7	6	4	6	1	2			73 (13%)
Moderate				1	2	7	4	1	5	6	12	5	3	1			47 (8%)
Severe			1	2	4	7	3	4	6	9	7	3		1			47 (8%)

Pain Severity by Age

B		Gender		Total
		Female	Male	
Pain Severity	None	201	215	416 (71%)
	Mild	34	39	73 (13%)
	Moderate	33	14	47 (8%)
	Severe	22	25	47 (8%)

Pain Severity by Gender

	C	DMFT											Average DMFT	Total
		0	1	2	3	4	5	6	7	8	9	10		
Pain Severity	None	247	72	45	16	14	8	4	7	1	1	1	0.99	416 (71%)
	Mild	35	13	7	9	5	1	2		1			1.37	73 (13%)
	Moderate	20	7	5	6	1		1	6	1			2.02	47 (8%)
	Severe	14	9	7	8	3	3	2		1			2.02	47 (8%)

Pain Severity by DMFT

had both dmft/DMFT scores of 1 or greater and pain severity from mild to severe (*Table 3C*). Children with gingival inflammation (428/583; 73%) had a dmft/DMFT score of 1.32, whereas children that had no gingival inflammation (155/583; 27%) had a dmft/DMFT score of 0.83 (*Table 5A*). A total of 210 (36%) children exhibited both dmft/DMFT scores of 1 or greater and gingival inflammation from mild to severe. In addition, children with gingival recession (18/583; 3%) had a dmft/DMFT score of 0.83 and children with no gingival recession (565/583; 97%) had a dmft/DMFT score of 1.18

***Table 4**. Gingival Inflammation and Recession by Age and Gender Distribution. A. Table reporting the numbers of children with different levels of gingival inflammation by age distribution. B. Table reporting the numbers of children with different levels of gingival inflammation by gender. C. Table reporting the numbers of children with different levels of gingival recession by age distribution. D. Table reporting the numbers of children with different levels of gingival recession by gender.*

A		Age																Total
		3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
Gingival Inflammation	None	2	9	12	12	11	11	10	16	8	14	27	16	6	2	1		155 (27%)
	Mild		7	20	22	30	37	32	32	30	37	57	28	14	11	1		360 (62%)
	Moderate		2	1	4	4	10	7	2	6	4	6	11	6	2	1		67 (11%)
	Severe																1	1 (.002%)

Gingival Inflammation by Age

B		Gender		Total
		Female	Male	
Gingival Inflammation	None	83	72	155 (27%)
	Mild	179	181	360 (62%)
	Moderate	27	40	67 (11%)
	Severe	1		1 (.002%)

Gingival Inflammation by Gender

C		Age																Total
		3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	
Gingival Recession	Normal	2	18	33	38	46	56	48	49	43	54	85	51	2	15	3	1	565 (96%)
	Mild								1		1	5	3	3				13 (2%)
	Moderate						1	1					1					3 (.005%)
	Severe						1			1								2 (.003%)

Gingival Recession by Age

D		Gender		Total
		Female	Male	
Gingival Recession	None	284	281	565 (96%)
	Mild	5	8	13(2%)
	Moderate	1	2	3 (.005%)
	Severe		2	2 (.003%)

Gingival Recession by Gender

***Table 5.** Gingival Inflammation and Gingival Recession by DMFT and Pain Distribution. A. Table reporting the numbers of children with different levels of gingival inflammation by DMFT distribution. B. Table reporting the numbers of children with different levels of gingival recession by DMFT distribution. C. Table reporting the numbers of children with different levels of pain distributed by levels of gingival inflammation. D. Table reporting the numbers of children with different levels of pain distributed by levels of gingival recession.*

A		DMFT					Average DMFT	Total
		0	1-2	3-5	6-8	9-10		
Gingival Inflammation	None	98	34	22	1		0.83	155 (27%)
	Mild	196	109	38	15	2	1.32	360 (62%)
	Moderate	22	22	13	10			67 (11%)
	Severe					1		1 (.002%)

Gingival Inflammation by DMFT

B		DMFT					Average DMFT	Total
		0	1-2	3-5	6-8	9-10		
Gingival Recession	None	308	157	73	25	2	1.18	565 (97%)
	Mild	7	5	1			0.83	13 (2%)
	Moderate		2		1			3 (.005%)
	Severe	1	1					1 (.002%)

Gingival Recession by DMFT

C		Pain Severity				Total
		None	Mild	Moderate	Severe	
Gingival Inflammation	None	123	16	6	10	32 (5%)
	Mild	250	45	32	33	110 (19%)
	Moderate	43	11	9	4	24 (4%)
	Severe		1			1 (.002%)

Gingival Inflammation by Pain Severity

D		Pain Severity				Total
		None	Mild	Moderate	Severe	
Gingival Recession	None	403	72	44	46	565 (96%)
	Mild	10	1	2		13 (2%)
	Moderate	2			1	3 (.005%)
	Severe	1		1		2 (.003%)

Gingival Recession by Pain Severity

Table 6. *DMFT by Pain, Gingival Inflammation, and Gingival Recession Distribution. Table reporting the number of children with different levels of DMFT, pain, recession, and inflammation coincidently.*

A											
Recession		None				Mild (1-2mm)		Moderate (3-4mm)		Severe (>4mm)	
Inflammation		None	Mild	Moderate	Severe	Mild	Moderate	Mild	Moderate	Mild	Moderate
0	None	83	141	17		5				1	
	Mild	8	24	3							
	Moderate	4	12	2		2					
	Severe	3	11								
1-2	None	27	73	11		3	2		1		
	Mild	2	15	3							
	Moderate	1	8	2							1
	Severe	4	10	1					1		
3-5	None	12	19	7							
	Mild	6	6	1	1		1				
	Moderate	1	4	2							
	Severe	3	9	2							
6-8	None	1	5	5				1			
	Mild			3							
	Moderate		6	2							
	Severe		3								
9-10	None		2								
	Mild										
	Moderate										
	Severe										
DMFT	Pain										

DMFT, Pain, Gingival Inflammation, Gingival Recession

	DMFT, Pain, Inflammation and Recession	DMFT, Pain, Inflammation	No DMFT, No Pain, No Inflammation, No Recession
Total Participants	3 (.005%)	78 (13%)	83 (14%)

(*Table 5B*). In addition, 135 (23%) children with pain also had gingival inflammation coincidently (*Table 5C*), however, only 5 (.01%) children with pain had gingival recession (*Table 5D*). Furthermore, 78 (13%) children exhibited all three parameters of oral disease coincidently, including a dmft/DMFT score of 1 or greater, pain, and gingival inflammation, whereas only

3 (.005%) children exhibited a dmft/DMFT score of 1 or greater, pain, gingival inflammation, and gingival recession (*Table 6*). These latter groups represent the children with the most dental disease. The healthiest children with dmft/DMFT scores of zero, and no pain or gingival inflammation or recession were a group of 83 (14%) children.

Discussion

Dental caries prevalence (46%) and dmft/DMFT scores (average 1.2; 6 to 8 year olds 1.7 and 15 to 18 year olds 1.02) children in this rural Kithoka region of Meru, Kenya are comparable to other Kenyan populations. In a study of 512 primary public school children in Nairobi, Kenya 46% of the 6 to 8 year olds and 50% of the 13 to 15 year olds had caries. The mean dmft in the 6 to 8 year olds was 1.7 and the mean DMFT in the 13 to 15 year olds was 1.8. The d and D components were predominant and only 1% and 10% were f or F, respectively [6]. In a more recent study of 12-year-old primary public school children in Nairobi, Kenya, the prevalence of dental caries was reported as 37.5% in the Nairobi West District and 24.0% in the Mathira West District [7]. The DMFT in Nairobi West was 0.76 ± 1.2 and in Mathira West it was 0.36 ± 0.7. Consumption of soda was attributed to the higher caries risk in the Nairobi West population. In the Kitale municipality in North-Western Kenya, a study of 12 year old children showed a 50.3% caries prevalence and a mean DMFT of 0.92 in this region [8]. A study on 245 children aged 12-18 years from a pastoral community in Kenya, found that caries prevalence was 52% with a mean DMFT of 1.9 ± 2.7. Among those with caries, the mean DMFT was 3.0 ± 2.0 [9]. In another study of 800 patients, average age of 9 years, examined in the Department of Paediatric Dentistry clinic at the University of Nairobi Dental Hospital, 73.8% had dental caries and the average number of teeth with decay was 3.71 [10]. A retrospective study of dental clinic records in a private practice setting evaluated data on 800 patients aged 0-18 years and found that 68.6% had dental decay and the average number of decayed teeth was 4.02 [11]. Most carious lesions occurred in younger children and there was a significant increase in the occurrence of decay over the three-year period of the study. In a cross-sectional study in HIV-infected children aged 3-15 years in Kenya, the prevalence of dental caries was reported as 65%, whereas the prevalence in deciduous teeth was 50% and in permanent teeth it was 30.9%. The mean dmft and DMFT scores in this population were 1.75 and 1.08, respectively [12]. A study of 449 handicapped children, aged 5-15 years, attending special schools in Nairobi found a caries prevalence of 44% and a mean DMFT of 0.8 in these children with caries severity increasing with age [13]. Another study on children, found a higher caries prevalence in children living in urban areas compared to those in rural areas [14]. Thus, the dental caries experience in the rural Kithoka region of Meru Kenya is comparable to that found in both rural and urban settings of Kenya. This finding probably reflects the low dentist-to-population ratio (1:378,000) and the scarcity of dentists practicing in Kenyan rural areas, reported as only 20% [1].

Gingival disease prevalence (75.1%) in children in the Kithoka community of Meru is comparable to other Kenyan populations. Gingival disease prevalence in Kenya differs depending on the setting. In a study on oral hygiene practices and periodontal health in 513 primary public school children in Nairobi, Kenya, 25% of the indexed tooth surfaces had gingivitis and 75% of the indexed tooth surfaces in the younger and 55% in the older age group had visible plaque [15]. In another study of 800 patients examined in the Department of Paediatric Dentistry clinic at the University of Nairobi Dental Hospital, 34.4% of the children had gingivitis [10]. In the Kitale municipality in North-Western Kenya, a study of 12 year old children found the prevalence of gingivitis was 77.7%, and 38.7% of these children required professional scaling and oral prophylaxis [8]. A retrospective study of dental clinic records in a private practice setting evaluated data on 800 patients aged 0-18 years and found that 36.8% had gingivitis [11]. A study on 449 handicapped children in Nairobi found gingivitis in 37% of the children and plaque present in all sites examined [13]. A study of acute Necrotizing Gingivitis (NUG) among patients (ages 1.5-46 years; mean 14.5 years; with 58.5 % below 11 years) in the dental unit at Kenyatta National Hospital in Nairobi, Kenya found that 0.15% had NUG [16].

Pain prevalence (29%) in children in the Kithoka community exceeds reported values for US children 10.7-14% (8.), however these values fall within Kenyan norms. In a study of 800 patients examined in the Department of Paediatric Dentistry clinic at the University of Nairobi Dental Hospital, 31.5% complained of pain, which was the most frequently presenting complaint [10]. In a study in HIV-infected children in Kenya, children with high dmft scores also had negative impacts in terms of appearance, chewing, biting hard foods, and missing school due to toothache and discomfort [12].

Endemic fluorosis has been a public health concern in many parts of Kenya as a result of the high fluoride content in the drinking water [17-20]. Fluorosis prevalence (29%) in the children of the Kithoka community of Meru falls within US reported values ranging from 1.7 to 33% [21], however compared to other areas of endemic fluorosis in Kenya, it is similar or lower. A study of dental fluorosis and caries on 275 adolescents aged 13-15 years in a peri-urban primary school in Nairobi, Kenya found that that caries experience significantly increased as the fluorosis score increased [22]. Specifically, 175 individuals had a fluorosis score (Thylystrup Fejerskov Index; TFI) of zero with a corresponding DMFT for dental caries of 1.3 ± 1.03 and 88 individuals had a mild to moderate severity of fluorosis (TFI score 1-4) with a corresponding mean DMFT of 1.53 ± 1.005 for dental caries. In addition, 82 individuals had severe dental fluorosis with TFI scores 5-9 and a corresponding DMFT of 1.85 ± 1.24 for dental caries. In another study on 76 children in a low-income rural community near Nairobi, 29% of children with high fluoride (9 ppm) content in their water had fluorosis scores (TFI) of 5 or higher compared to 7% of children with low fluoride (less than 0.7 ppm) in their drinking water [23]. In a larger study of 513 primary school children in Nairobi, 18% of 6-8 year olds had dental fluorosis in the primary dentition and 76% of 13-15 year olds in the permanent dentition. The degree of fluorosis was very mild in children using river water (0.2-0.4 ppm F-), however in those using borehole water 48%

of the children and 40% of the teeth had TFI scores of 5 or greater [24]. A study of 102 children in a rural area of Kenya with 2ppm fluoride in the drinking water found that children exhibited a 100% prevalence of dental fluorosis with 92% percent of teeth showing a fluorosis score (TFI Index) of 4 or higher and 50% of the children had pitting or more severe enamel defects [25]. Another study found that fluorosis scores (TFI) increased with age, suggesting that even several years after tooth eruption there is a trend towards an increasing severity of enamel destruction in children in areas with high dental fluorosis [26].

Given that the dmft/DMFT scores in the children in Meru were almost exclusively comprised of decayed teeth (only 1% were filled), this underscores the urgent oral health needs in these children. Not surprising was the fact that approximately one third of the children were in pain at the time of examination. Thus, given the current findings (46% of children presenting with active carious lesions, 29% with pain, and 75.1% with gingival disease), and lack of access to care, focus needs to be placed on prevention of dental decay and gingival inflammation, especially at an early age in this region of Kenya. There are only a few dentists providing care in the entire Meru area, which has a population of 1,356,301. Therefore, it is important to establish programs that will prevent decay in the young children in this region.

The World Health Organization (WHO) identified caries as one of the most prominent infectious diseases in the world, affecting 60-95% of children—in developed and developing countries [27]. From a public health perspective, the rate of early childhood caries in developing countries is particularly alarming [28- 30]. More than 80 percent of the world's children live in developing countries where dental health care resources are extremely limited [31]. Although there are differences of opinion regarding the cause of this global increase in dental caries in this population, preventive strategies to address this problem are well known and include community-based fluoridation (e.g., drinking water and salt fluoridation), topical fluoride application at home or through dental offices or school programs, a diet low in fermentable carbohydrates, adequate plaque removal by daily tooth brushing, and regular dental office visits for screening, treatment, and oral health instruction [32-34].

Lack of effective prevention can have serious negative consequences on children's oral health that in turn could contribute to other early childhood problems, including malnutrition and poor school performance. The 2009 Kenya Demographic and Health Survey showed that 30 percent of children and youth are too short for their age, or stunted. Stunting indicates chronic malnutrition. Almost six percent of Kenyan children are wasted, or thin for their height [35]. Wasting is a sign of severe malnutrition. Overall, one in five children is under- weight in Kenya.

Stunting, wasting, and underweight are most common in rural areas and among families of lower socioeconomic status. The children in the rural community of Kithoka, where the current oral health survey was conducted, exhibit several levels of malnutrition, and although the relationship between oral health status and malnutrition in this community is unknown, this also warrants additional examination. In a pilot survey focused on nutritional health, a questionnaire was given to 85% of the student population at Gichunge Primary and 50% of the student population at Kithoka Primary [3]. The survey was comprised of 33 questions, divided into five sections consisting of information about family, and additional economic, social, educational and nutritional information. After the demographic survey was completed, 61% of the student population at Kithoka Primary and 89% of the students at Gichunge Primary were measured and weighed. This data was then interpreted using the Weight-for - Height reference table established by the WHO in 2009. Malnutrition rates were as followed: 9.9% severely malnourished, 11.8 moderately malnourished, 78.2% adequately nourished. Whether the oral health of these children contributes in any way to their nutritional status is currently unknown and future studies could help address this gap in knowledge.

Furthermore, given the additional burden that 29% of children also exhibited oral pain, this could contribute to multiple other problems for the children. Chronic oral pain could potentially lead to poor nutrition due to an inability to intake food that, in turn, can affect a child's growth and development. Oral pain can also cause children to miss school and lead to high levels of absenteeism and therefore poor school performance [36]. Oral pain can negatively impact learning due to an inability to focus and become distracted by the level of pain [37]. When evaluating the relationship between the impact of oral health on daily performances in primary school children in South Africa, there were direct correlations noted between negative oral health and daily performance. Out of the 64% of the participating children aged 11-13 years, 36.2% reported having one or more oral impacts on daily performances, eating was most commonly affected (22.8%) and toothache impacted speaking and studying [37]. In Nairobi, a study that looked at dental caries and oral health practices among 12 year old children reported that a school health policy should be used to promote oral health through oral health instruction. Preventive practices should be advocated and promoted in the schools [7]. Thus, addressing and preventing oral pain as relates to dental decay is important for many aspects of the overall well-being of the children in this community.

In summary, the level of oral disease present in children in the Kithoka region of Meru, Kenya is comparable to that in other parts of Kenya and other developing countries, however, this presents almost exclusively as an unmet need. This unmet need negatively impacts the children and families in this community in many ways that are both obvious and tangible but also in ways that are less apparent and perhaps downstream. Thus, it is paramount that local health, education, and funding agencies take stock of the impact that oral health can have on its communities and its future development.

Acknowledgements

This project was supported by grant #2UL1TR000433 from the National Center for Advancing Translational Sciences (NCATS), University of Michigan School of Dentistry, and The International College of Dentists. We wish to thank the local community in Kithoka, Meru, including KeMU and the Thiri Center for their

support. A special thank you to Peter Ndege's colleagues at Kenya Methodist University for their direct support throughout this project. We also wish to thank Daniel Clauw, Marianne Clauw, Thomas Nyongesa, Michael Manz, Marilyn Brenchley, Bishop Lawi Imathiu and the many students from the Kithoka community, from the University of Michigan, and other group members that helped with surveys or other aspects of this program over the years that made this study possible, including, James Musselwhite, Jami Ballentine, Lauren Ehardt, Priyanka Iyer, Laura Lungu, Alisha Paal, Alexandra Petrazko, Jesse Plummer, Ovy Quintinal, Dan Valicevic, Ashley Greene , Aaron Ruhlig, Mark Shallah-Ayzin, Nathan Poel, Anjuli Kapila, Sahil, Kapila, and Simran Kapila.

Availability of Supporting Data

Supporting data are now available in the open access repository website (http://www.labarchives.com/) at the following URL:https://mynotebook.labarchives.com/share/Data%2520Research%2520Files/MTkuNXw1ODI0NC8xNS0yL1RyZWVOb2RlLzM4MTYxMzU4MjZ8NDkuNQ==

Competing Interests

The authors declare that they have no competing interests.

Authors' Contributions

DF- helped with the study design, conducted exams and surveys, collected the data, and worked on manuscript drafts.

JT- helped with the data organization, data analyses, preparation of figures, wrote statistical section of the manuscript, and worked on manuscript drafts.

JC- helped with the study design, conducted exams and surveys, collected the data, and worked on manuscript drafts

JD- helped with the study design, set up the initial electronic survey, conducted exams and surveys, and collected the data.

SK-helped with the study design, helped with overall coordination of study team, helped with data collection, helped with manuscript preparation.

RE- helped with the study design, helped with overall coordination of study team, helped with data collection, helped with manuscript preparation.

CGC- helped with the study design, helped with overall coordination of study team, helped with data collection, helped with manuscript preparation.

PN- helped with overall coordination of study team on site in Kenya, helped with data collection, helped with manuscript preparation.

MP-provided pilot survey data focused on nutritional health on the same study population, contributed to manuscript drafts.

SP- provided pilot survey data focused on nutritional health on the same study population, contributed to manuscript drafts.

YLK- helped with the study design, helped with overall coordination of study team, conducted exams and surveys, helped with data collection, wrote and revised manuscript drafts after receiving drafts and comments from all the authors, put final manuscript together.

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