Dental caries experience in adults: a cross-sectional community survey within Ethiopia

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Abstract

Background Ethiopia is a large and diverse developing sub-Saharan African country with increasing prevalence of non-communicable diseases, including oral conditions. Oral health and dental care have been given little consideration, and there is limited information relating to population oral health and use of dental services in the country. The aim of this study was to examine the burden and impact of dental caries experience and investigate access to dental care amongst adults within Ethiopia.

Methodology This community-based oral health survey is a baseline study for the ASSET - Health System Strengthening in sub-Saharan Africa project undertaken in the Butajira area, south-central Ethiopia. A stratified random sample of households and individuals were participated in the study. The survey was informed by the World Health Organization (WHO) Oral Health Survey Methods (5th ed.) at International Caries Detection and Assessment System (ICDAS) threshold 4 and the UK Adult Dental Health Survey 2009. Face-to-face interviews and clinical dental examinations were conducted. The data were analysed using descriptive statistics; and a binary logistic regression model was built to assess the association of dental caries and predictor variables: demographics, health behaviours, quality of life, dentition status and consequences of untreated caries data in adults (≥18 years).

Result Most of the study population (n=626) were female (63.9%), married (71.4%) and Muslim (76.0%). Just over half (53.2%) lived in rural areas and many (44.4%) had no formal education. A majority (74.0%) reported never attending a dental service. Sixty percent (n=377) of the adults had experienced dental caries, 88.0% (n=332) of whom had untreated carious teeth. In the fully adjusted logistic regression model; increasing age, dental attendance and Khat chewing had a positive significant association with dental caries experience, whilst education status was negatively associated (p<0.05).

Conclusion This study demonstrated a high burden of dental caries and considerable impact resulting from untreated disease in this population of adults. There was also evidence of social inequity and limited overall access to dental care, highlighting the need for health system strengthening.

Background

Oral health is an integral element of good health and wellbeing as it facilitates essential functions, most notably: eating, speaking, smiling, and socialising (1). Oral conditions, especially dental caries and periodontal diseases are considered major global public health problems (2–4). Although mostly preventable and treatable, they can be life threatening. About 90% of the world population face at least one form of oral condition sometime in their lives and oral conditions have been associated with adverse socioeconomic impact in both adults and children irrespective of their gender (5). Overall, untreated caries in secondary teeth, primary teeth and severe chronic periodontitis are the top three most prevalent oral disorders (6).

Oral health in Africa has been considered a low priority in relation to communicable diseases. However, non-communicable diseases (NCDs), under which common oral conditions are classified, are increasing across the continent (7). In a 2015 report on the severity and prevalence of oral conditions in the Africa/Middle East Region (AMER), reliable data were found to be scarce, but there was evidence of an increasing burden of oral diseases with related morbidity. There are substantial oral health inequalities in both high- and low-income nations and the prevalence of dental caries, periodontal diseases, orofacial trauma and oral cancer, as well as Noma, are increasing (8). This is mainly related to specific risk factors associated with nutritional transitions - transition towards the 'Western diets' involving increased sugar consumption - together with low fluoride availability and inadequate dental care, in addition to other general factors including age, socioeconomic status and area of residence (9).

Ethiopia is a large, diverse low-income sub-Saharan African country in the east African region with rich natural resources and history. It has one of the world's fastest growing economies with a rapid real domestic product growth despite the low Gross Domestic Product (GDP) per capita (10). Agriculture engages nearly 85% of the country's workforce and many economic activities depend on it, with most of the population living in rural areas. Considerable economic and health inequalities exist between the urban and rural populations nationally (11). Ethiopian oral health data are notably scarce as there are no community-based epidemiological oral health surveys. However, local hospital and school-based cross-sectional studies suggest untreated dental caries present a problem. First, in two local studies in north-western Ethiopia, untreated dental caries were identified in about one-third and one-fifth of schoolchildren aged 7–14 and 6–15 years, respectively, whereby the disease was positively associated with toothache, and negatively associated with oral hygiene, household income and paternal education (12, 13). Second, findings from hospital attendees, involving children and adults, indicate that dental caries, which affected three-quarters of attendees, was the most frequent reason for presentation at the dental service (14, 15).

Healthcare in Ethiopia is improving, and the government has made substantial investment aligned with the sustainable development goals to strengthen the public healthcare services to improve population health (16); however, change will take time. Access to health services in general is harder for the rural population (17, 18). Furthermore, dental services in particular are very limited, predominantly found in the private sector as well as in secondary and tertiary referral public hospitals which are largely located in the cities and bigger towns (19, 20), with implications for patient access.

Africa itself possesses only 1% of the global dental workforce (21, 22) and has a dentist: population with a ratio of around 1: 40,000. Ethiopia's dentist-to-population ratio has historically been extremely low at 1:1.5 million population. Besides, inter-regional disparities are common and particularly between urban and rural areas (21). The relatively recent establishment of dental education in Ethiopia with three public dental schools across the country and the private education sector in the capital means that numbers are growing, and the country is no longer completely reliant on people studying abroad. However, current workforce data are not available. In addition, as with other sub-Saharan African countries, Ethiopia loses its high-end healthcare professionals due to migration to more developed countries, and the supply does not match the demand because of the low retention (23, 24). This, together with the wider social determinants (25), such as individual lifestyle, community influences, working and living conditions; and the more general social conditions in Ethiopia (26), contribute to the volume of untreated disease including oral conditions (3).

The 'Health System Strengthening in sub-Saharan Africa – ASSET' project in Ethiopia is led by King's College London within the NIHR Global Health Research grant. It is a collaborative project with Addis Ababa University, and it provides an opportunity to support the country's healthcare system through health system strengthening interventions across its three phases: diagnostic, piloting and implementation. The aim of the dental component within the diagnostic phase of the surgical care survey was to examine the burden of oral disease and explore access to dental care and its possible barriers in a rural and urban population within Ethiopia to inform health system strengthening. This will be facilitated using the baseline information to inform the second and third phases of the ASSET project successively.

In light of the above, the aim of this paper is to report the burden and impact of dental caries experience and to investigate access to dental care amongst adults within Ethiopia.

Methods And Materials

This community oral health survey was part of the surgical care survey of the ASSET project in Ethiopia. Whilst we collected epidemiological data from children and adults using standardised questionnaires and clinical oral examinations during March 2019, this paper includes data from adults only.

Study Area and Population

The study was conducted in districts across the Butajira Health and Demographic Surveillance Site (HDSS), south-central Ethiopia. The Butajira HDSS is found in Meskan and Mareko districts in the Gurage zone, Southern Nations, Nationalities, and Peoples' Region (SNNPR) of Ethiopia. It covers nine rural and one urban sites, with a total of 40,000 people and an area of approximately 797 km^2, of which 9 km^2 is Butajira town - the only urban site of the HDSS. Butajira is located 130 km south of the capital Addis Ababa. The main source of income for the rural population in the HDSS is farming. The production mainly includes Teff (a cereal staple), barley, millet, legumes and maize on the rich soil of the area, with the staple food of Enset (false banana). Butajira also grows coffee, chilli peppers and Khat (a mild stimulant drug) as cash crops (27). This area was chosen for the project as it has an established rural health programme and it provides a study base for essential health research and intervention.

The sample population for this study was drawn from and stratified across the seven accessible sub-districts (*kebeles*) of Butajira town and Meskan district (*woreda*) using stratified random sampling of individuals and households. Civil unrest prevented access to the remaining HDSS sites. The sample size, calculated for the ASSET surgical community survey, was 1200: 2 persons of any age, randomly selected from 600 households.

Participants included in this study were those living in Butajira HDSS for at least 1 year prior to the survey and able to communicate in the working language of Amharic. The adult participants were those willing to participate in the study and provide written consent. People with serious health conditions, making it difficult to comply with the interview and oral examination, were excluded from the study.

Instruments and Measures

The 5th edition of World Health Organisation (WHO) Oral Health Survey Methods (5th ed.) (28) formed the basis for the survey methodology and the standard instruments (electronic questionnaire and data collection forms) were developed drawing on the latest epidemiological research methods: the UK (England, Wales and Northern Ireland) adult dental health survey 2009 (29), and the International Caries Detection and Assessment System (ICDAS) dental caries scoring system (30).

Dental caries experience at tooth level, and the consequences of untreated caries are the main dependent variables. Dental caries experience was determined using the globally accepted DMFT index (the presence of Decayed, Missed and Filled Teeth) extracted from the dentition status data (28). Assessment of dental caries was based on the WHO survey guideline 'tooth condition' assessment format (28), and the threshold of individual lesions was determined using the International Caries Classification and Management System (ICCMS), ICDAS coding criteria. We considered ICDAS 4 (D_4), and above as 'caries', because ICDAS 3 (D_3) and below is more difficult to assess when only visual examination is used without clinical/diagnostic facilities (30), particularly in areas where Khat chewing is common, as it can stain teeth after repeated use making early caries mode difficult to identify. Khat, a green leaf chewed for its mild stimulating effect, is commonly used in East-Africa and Middle-east region (31, 32).

To determine the consequences of untreated caries, we used the PUFA index, presence of Pulpal involvement, Ulcer, Fistula and Abscess (PUFA) (33). We also assessed the presence of pain or any condition related to the chronic complication of dental caries as an additional outcome variable (29).

Sociodemographic factors included in the baseline surgical questionnaire instrument as important independent variables for subsequent analysis were as follows: age, sex, education status, religious affiliation, marital status and location (urban/rural) as these variables are common predictors of caries (34, 35). In relation to lifestyle and behavioural factors, frequency of tooth cleaning and materials used, including toothpaste were collected in the dental data collection instrument and used as proxies for oral hygiene/plaque removal and fluoride exposure (36, 37). Other health behavioural and lifestyle factors examined because of their influence on oral health were: Khat chewing, sugar, tobacco and alcohol consumption (9, 38). Self-reported dental attendance, which refers to attending a recognised dental service provider, was also obtained to look at access to dental care and possible barriers to care (14, 39).

Standardization

The dental questionnaire instrument was translated into the working language of the area – Amharic. It was also back translated into English by two native Amharic speakers with full professional competencies in English. They were non-dental/medical professionals with no knowledge about the survey. The original and translated questionnaires were then assessed if they achieve semantic and conceptual equivalence, and it did not require any further amendment.

The clinical examiners (dentists) were trained over a two-day period and calibrated for identification and assessment of dental caries on the same set of teeth. Inter-examiner agreement was computed using the kappa statistics, with a range of 0.6-1.0 (mean: 0.96). A standard form was created online for recording of the clinical data. Repeat examinations were not possible because of time and logistical constraints.

Data Collection

Lay data transcribers and dentists teamed up with their surgical community survey counterparts during the data collection. Participants were interviewed face-to-face and examined for oral diseases in their respective households. The transcribers recorded all information (questionnaire and clinical oral examination) using the Open Data Kit (ODK) software on smart phones. Oral examination was visual, conducted using standard disposable dental mirrors and blue-white spectrum solar headtorches with the examinee supine. Dental probes were only used for removing debris, when required.

Data Entry, Cleaning and Analysis

The ASSET data specialist exported the data and merged the surgical and dental data using unique identifier codes to form the datasets for analysis. We then cleaned the dental data removing any incomplete cases related to this analysis, created new variables and undertook data analysis using SPSS version 25. The numerical variable–age was recoded into six age-bands (28), and the variable dental caries experience was categorized in to $D_4MFT = 0$ and $D_4MFT \geq 1$ prior to the data analysis. Sugar consumption 'risk' was also calculated based on the frequency of reported intake of sweets, cakes, biscuits and soft/fizzy drinks. Consuming at least one of them more than once a week was categorised as 'higher-risk', between once a month and once a week as 'moderate-risk', and rarely or never as 'lower-risk' consumption.

The sociodemographic characteristics, health behaviours and other relevant data were summarized using descriptive statistics. We used frequencies and proportions to describe the variables and used a chi-square test to examine the association between the independent and dependent variables outlined above. The association of health behaviours, tooth cleaning habit and the sociodemographic factors with dental caries experience were further analysed using both unadjusted and adjusted binary logistic regression models.

Results

Of the 1071 people who participated in the study (89.3% response rate), 650 were adults. Twenty-four adult participants (3.8%) were excluded from the final analysis because of missing relevant information. Therefore 626 participants, with an average age of 38.4 years (range: 18–100; sd: 16.4 years) were included for analysis. A higher proportion of the study population was female (63.9%, n = 400), married (71.4%, n = 447), and Muslim (76%, n = 476). Just over half (53.2%, n = 333) lived in rural areas and 44.4% (n = 278) had not received any formal education.

Reported health behaviours were largely positive. The vast majority (97.9%, n = 613) reported never smoking cigarettes or drinking alcohol (90.4%, n = 566), or chewing Khat (59.0%, n = 370); sugar consumption was generally low with only 10.7% (n = 67) in the 'higher-risk' category (consuming any sweet more than once a week). However, tooth cleaning twice a day or more was only practiced by about one in five adults, as was toothpaste use. Chew-sticks (Mefakiya) were most commonly used for tooth cleaning (45.0%, n = 281).

A majority (74.0%, n = 463) of participants had never been to a dental service. The main reported reason for not attending a dental service was never experiencing any dental pain/problem (71.3%, n = 330), followed by the distance to a dental clinic/service (9.3%, n = 58) and the cost of treatment (8.2%, n = 51). Only 37.1% (n = 140) of those with dental caries experience reported attending a dental service.

Dental caries experience D_4MFT and its consequences in relation to demographic and behavioural variables are presented in Table 1. Six out of ten (60.2%, n = 337) of adults surveyed had a D_4MFT score of 1 or more, out of which 88.0% (n = 332) had at least one untreated obvious carious tooth (D_4T) which accounts for 53.0% of the total study population.

Table 1
Bivariate analysis of dental caries experience and consequences of untreated dental caries (D$_4$MFT ≥ 1)[a] with sociodemographic and relevant health behavi... factors of adults in Butajira HDSS, south-central Ethiopia

Factors		Total		DT ≥ 1			MT ≥ 1			DMFT ≥ 1			Pain/Discomfort			PUFA ≥ 1	
		N	%	n	%	p-value	N	%	p-value	N	%	p-value	N	%	p-value	n	%
Total		**626**	**100**	**332**	**53.0**		**188**	**30**		**377**	**60.2**		**103**	**16.5**		**45**	**7.2**
Age group	18−24	123	19.7	35	28.5	0.001	5	4.0	0.001	36	29.3	0.001	8	6.5	0.001	7	5.7
	25−34	190	30.4	70	36.8		39	20.5		85	44.7		22	11.6		13	6.8
	35−44	103	16.5	65	63.1		30	29.1		78	75.7		17	16.5		3	2.9
	45−54	79	12.6	56	54.4		36	35.0		61	59.2		18	22.8		8	10.1
	55−64	74	11.8	59	79.7		40	54.0		64	86.5		26	35.1		9	12.2
	65+	57	9.1	47	82.5		38	66.7		53	93.0		12	21.1		5	8.8
Sex	Female	400	63.9	213	53.3	0.886	126	31.5	0.165	240	60.0	0.932	65	16.3	0.911	28	6.0
	Male	226	36.1	119	52.7		62	27.4		137	60.6		38	16.8		17	7.5
Education level	No formal education	278	44.4	205	73.7	0.001	121	43.5	0.001	226	81.3	0.001	65	23.0	0.001	19	6.8
	Primary school	202	32.3	88	43.6		47	23.3		102	50.5		23	11.4		16	7.9
	Secondary school	97	15.5	26	26.8		14	14.4		34	35.1		11	11.3		8	8.3
	Higher education	49	7.8	13	26.5		6	12.2		16	32.7		4	8.16		2	4.1
Religion	Muslim	476	76.0	261	54.8	0.183	149	31.3	0.135	296	62.2	0.166	76	16.0	0.810	31	6.5
	Orthodox	131	21.0	62	47.3		37	28.2		72	55.0		24	18.3		12	9.2
	Protestant	19	3.0	8	42.1		2	10.5		9	47.4		3	15.8		2	10.5
Marital Status	Single/Never Married	106	16.9	30	28.3	0.001	10	33.3	0.001	32	30.2	0.001	8	7.6	0.017	2	1.9
	Married	447	71.4	242	54.1		134	55.4		278	62.2		79	17.7		37	8.3
	Formerly Married	73	11.7	60	82.2		44	60.3		67	91.8		16	21.9		6	8.2
Location	Urban	293	46.8	127	43.3	0.001	81	27.7	0.222	154	52.6	0.001	37	19.8	0.015	23	7.9
	Rural	333	53.2	205	61.6		107	32.1		223	66.8		66	23.0		22	6.6
Dental attendance	Never	463	74.0	212	45.8	0.001	100	21.6	0.001	237	51.2	0.001	66	14.3	0.012	26	5.6
	Ever	163	26.0	120	73.6		88	54.0		140	85.9		37	22.7		19	11.7
Factors		Total		DT ≥ 1			MT ≥ 1			DMFT ≥ 1			Pain/Discomfort			PUFA ≥ 1	
		N	%	n	%	p-value	N	%	p-value	N	%	p-value	N	%	p-value	n	%
Frequency of tooth cleaning	Never/Rarely	65	10.4	48	73.9	0.001	27	41.5	0.007	51	78.5	0.001	9	13.9	0.001	2	3.1
	Less than once a day	305	48.7	156	51.2		79	25.9		178	58.4		50	16.4		15	4.9
	Once a day	135	21.6	53	39.3		35	25.9		65	48.2		15	11.1		8	5.9
	Twice or more per day	121	19.3	75	62.0		47	38.8		83	68.6		83	68.6		20	16.5
Tooth cleaning Material	Mefakiya/Chewstick[b]	281	44.9	150	53.4	0.001	87	31.0	0.004	169	60.1	0.001	53	18.9	0.288	20	7.1

[a] DT: ICDAS 4 and above [b] Mefakiya: an Amharic name for chew-stick

[c] More than once a week [d] Between once a month and once a week [e] Rarely or never

Factors		Total		DT ≥ 1			MT ≥ 1			DMFT ≥ 1			Pain/Discomfort			PUFA ≥ 1	
		N	%	n	%	p-value	N	%	p-value	N	%	p-value	N	%	p-value	n	%
	Wooden toothpicks	142	22.7	75	52.8		45	31.7		89	62.7		22	15.5		7	4.9
	Toothbrush	114	18.2	44	38.6		19	16.7		52	45.6		13	11.4		10	3.1
	Other	24	3.8	15	62.5		10	41.7		16	66.7		6	25.0		6	7.1
	Do not clean	65	10.4	48	73.9		27	41.5		51	78.5		9	13.8		2	4.9
Use of toothpaste	Yes	118	18.9	42	35.6	0.001	17	14.4	0.001	50	42.4	0.001	14	11.9	0.260	8	8.8
	No	443	70.8	242	54.6		144	32.5		276	62.3		80	18.1		35	25.0
	Do not clean	65	10.4	48	73.9		27	41.5		51	78.5		9	13.8		2	3.1
Frequency of Khat Chewing	Never Chew	370	59.1	164	44.3	0.001	90	24.3	0.003	193	52.2	0.001	54	14.6	0.484	23	6.2
	Less than weekly	72	11.5	43	59.7		26	36.1		48	66.7		13	18.1		8	11.1
	More than once a week	101	16.1	64	63.4		40	39.6		70	69.3		19	18.8		8	7.9
	Every day or nearly every day	83	13.3	61	73.5		32	38.6		66	79.5		17	20.5		6	7.2
Level of sugar consumption risk	Higher[c]	67	10.7	31	46.3	0.004	13	19.4	0.017	35	52.2	0.001	9	2.0	0.733	4	0.1
	Moderate[d]	223	35.6	102	45.7		59	26.5		115	51.6		36	0.4		20	20.0
	Lower[e]	336	53.7	199	59.2		116	34.5		227	67.6		58	68.2		21	24.7
Toothache or discomfort (in past 12 months)	Often	44	7.0	37	84.1	0.001	24	54.6	0.001	38	86.4	0.001	22	0.5	0.001	12	27.3
	Occasionally	133	21.3	104	78.2		58	43.6		113	85.0		50	37.6		14	10.5
	Rarely	97	15.5	66	68.0		35	36.1		75	77.3		14	14.4		4	4.1
	Never	352	56.2	125	35.5		71	20.2		151	42.9		16	4.6		14	4.1

[a] DT: ICDAS 4 and above [b] Mefakiya: an Amharic name for chew-stick

[c] More than once a week [d] Between once a month and once a week [e] Rarely or never

Table 1. **Bivariate analysis of dental caries experience and consequences of untreated dental caries ($D_4MFT ≥ 1$)[a] with sociodemographic and relevant health behavioural factors of adults in Butajira HDSS, south-central Ethiopia**

D_4MFT scores ranged from 0−28 (mean, 4.4 ± 6.9), and the score increased with age (Fig. 1). Only 0.8% (n = 3) of adults with dental caries experience had fillings, but 49.9% (n = 188) of them had missing teeth. Pain and/or discomfort was reported by 16.5% (n = 103), with 7.2% (n = 45) having one or more PUFA component. Most (59.9%, n = 226) adults with dental caries experience reported some tooth pain and/or discomfort during the last year.

Fig. **Progression of dental caries experience (DT: ICDAS 4 and above) across the age categories of adults in Butajira HDSS, South-central Ethiopia**

Based on the bivariate analysis, increasing age had a significant and positive association with dental caries experience; whereas educational level was negatively associated. Marital status and location also demonstrated highly significant associations with caries (p < 0.001 for all). However, no association was observed with sex and religion. Regarding the health behaviours, dental attendance, frequency of tooth cleaning and materials used (including the use of toothpaste), sugar intake and Khat chewing were highly associated with dental caries experience (P < 0.001 for all). There were also significant associations between the health impact, notably tooth pain/discomfort related to untreated dental caries and age, education, marital status, dental attendance, location and tooth cleaning frequency (p < 0.05). Out of all the independent variables, only dental attendance, tooth cleaning frequency and materials used for dental hygiene were significantly associated with PUFA (p < 0.05).

The binary logistic regression models for dental caries experience and predictors are presented in Table 2. In the unadjusted model, all the independent variables, except for sex, had significant associations with dental caries experience (p < 0.05). In the adjusted model, the odds of experiencing dental caries were higher in older age-groups, whilst the odds of dental caries experience were lower in higher levels of education. The odds of experiencing dental caries amongst those who reported attending dental services were seven times (95%CI: 3.9−12.1, p = 0.001) the odds of those who had never attended. Khat was the only lifestyle behavioural component that remained significant in the adjusted model; people who reported chewing Khat daily or nearly every day had four times (95%CI: 1.7−8.3, p = 0.001) the odds of experiencing dental caries as compared with reported non-chewers. Location of residence and other health behaviours including tooth cleaning, the risk of sugar intake, did not predict caries experience after adjusting for other factors.

Table 2
Factors associated with dental caries experience ($D_4MFT \geq 1$)[a] among adults in Butajira HDSS, South-central Ethiopia

Explanatory Variables		Unadjusted Model		Adjusted Model	
		OR[f]	95% CI	OR[f]	95% CI
Age group	18−24	1	[Reference]	1	[Reference]
	25−34	1.96**	1.21−3.17	1.09	0.61−1.97
	35−44	7.54***	4.16−13.67	2.89**	1.36−6.14
	45−54	8.19***	4.26−15.75	3.24**	1.41−7.43
	55−64	15.47***	7.15−33.45	3.95**	1.54−10.11
	65+	32.02***	10.79−95.05	10.56***	3.14−35.43
Sex	Female	1	[Reference]	1	[Reference]
	Male	1.03	0.74−1.43	1.29	0.75−2.20
Educational status	No formal education	1	[Reference]	1	[Reference]
	Primary school	0.24***	0.16−0.35	0.35***	0.20−0.62
	Secondary school	0.12***	0.07−0.20	0.24***	0.11−0.51
	Higher education	0.12***	0.06−0.22	0.22***	0.09−0.55
Location	Urban	1	[Reference]	1	[Reference]
	Rural	1.83***	1.32−2.53	0.98	0.61−1.58
Dental attendance	Never	1	[Reference]	1	[Reference]
	Ever	5.80***	3.60−9.35	6.83***	3.86−12.07
Frequency of tooth cleaning	Never/ Rarely	1	[Reference]	1	[Reference]
	Less than once a day	0.39**	0.20−0.73	0.92	0.32−2.60
	Once a day	0.26***	0.13−0.50	0.78	0.27−2.26
	Twice or more per day	0.60	0.30−1.21	1.48	0.50−4.45
Tooth cleaning material	Toothbrush	1	[Reference]	1	[Reference]
	Mefakiya/ Chew-stick[b]	1.80**	1.16−2.79	0.62	0.20−1.86
	Wooden toothpicks	2.00**	1.21−3.31	0.52	0.16−1.74
	Other	2.39	0.95−6.02	0.75	0.16−3.44
	Don't clean	4.34***	2.16−8.72	1.20	0.36−3.98
Use of toothpaste	Yes	1	[Reference]	1	[Reference]
	No	2.25***	1.49−3.42	1.33	0.446−4.00
Frequency of Khat chewing	Never	1	[Reference]	1	[Reference]
	Less than weekly	1.83	1.08−3.12	0.67	0.34−1.32
	More than once a week	2.07**	1.30−3.31	1.68	0.90−3.13
	Every day/nearly every day	3.56***	2.01−6.30	3.79***	1.73−8.31
Level of sugar consumption risk	Higher[c]	1	[Reference]	1	[Reference]
	Moderate[d]	0.97	0.56−1.68	0.78	0.39−1.56
	Lower[e]	1.90*	1.12−3.24	1.30	0.63−2.65

[a]DT: ICDAS 4 and above [b]Mefakiya: an Amharic name for chew-stick

[c]More than once a week [d]Between once a month and once a week [e]Rarely or never

[f]Binary Logistic Regression was fitted, and Odds Ratio was reported

*p < 0.05; **p < 0.01; ***p < 0.001

Discussion

In this cross-sectional study amongst a rural and urban population of south-central Ethiopia, six out of ten adults were found to have dental caries experience. This study is one of the few oral health research projects to have been carried out in the country and the first population-based oral health survey to be part of a large multi-disciplinary global health project providing an overview of adult oral health in the community and the most extensive in nature. This research has certain limitations which need to be acknowledged. First, it was conducted in a relatively ethnically homogenous population, which therefore cannot be considered nationally representative. Second, almost half (46.8%) of the study participants were from the urban area due to the accessibility challenge in some rural areas. Since a large proportion (80.0%) of the general population in the country is rural, this again needs to be recognised as unrepresentative of the national situation; however, it allowed comparison between the rural and urban settings and given the study findings whereby the differences between urban and rural settings were not significantly different in the adjusted logistic regression model, this may not be a major factor. Third, the people who stayed at home and were available to participate in the data collection might be different from those who were out engaging in work and other activities and thus possibly overrepresented. However, every effort was made to ensure that people who worked away from home were included in the study, although most men working in the fields might have been missed. Fourth, the questionnaire data were collected by face-to-face interview, which means participants may have given more socially desirable answers about their lifestyle and behaviours. None-the-less, given the very low level of education in this community, this was the most appropriate survey method. Fifth, the sample size was calculated based on surgical care needs; however as surgical care needs are less common than oral diseases, this provided a substantial sample for the oral health survey when compared with other national dental surveys (29), and our findings will provide a sound basis to inform future epidemiological studies in Ethiopia.

The magnitude of untreated obvious caries (clinically visible lesions representing demineralisation in the middle third of the dentine, and above indicated by the ICDAS 4 threshold) in the study participants was high; if the early and sub-clinical lesions were included, which would require optimal clinical and radiographic examinations (40), a higher value would result. These findings suggest an increasing burden of NCDs in general (41). Interestingly, a higher proportion of dental caries experience was observed in rural areas, unlike a previous study in Ethiopia which reported a higher prevalence of caries in urban areas (61.1%) (14). However, the odds of experiencing dental caries were almost the same for both locations in the adjusted logistic regression model. Although rural areas are generally suggested to have less access to cariogenic foods, this may be changing with the nutrition transition in Africa; in addition to the limited access to dental care and preventive services as compared to urban areas. Similar issues exist in both lower and higher income countries, whereby the rural population has more untreated caries (35, 42).

In the study participants, the odds of experiencing caries increased with age and the pattern of the condition is also cumulative throughout life by its nature (34). This finding mirrors the emerging result of the Dunedin longitudinal study (the 1972/3 birth cohort) of dental caries trajectory assessment in which the participants dental caries experience in the different categories of the trajectory increased with age (43). However, there was no significant difference between males and females in our study regarding their dental caries experience unlike previous studies in the UK (44), but it is similar with the recent global burden of oral health study findings (6, 45).

In this regression model, the odds of experiencing dental caries significantly reduced with increasing educational attainment of adults. Education, being one of the social determinants of health can also influence an individual's position in the society and determine their income. This in turn influences the risk of one's exposure to different diseases (25), including dental caries in adults (34).

Health behaviours, whilst important risk factors for oral disease (9), are less likely to be significant in our model. Amongst the health behaviours assessed in this survey, chewing Khat daily was associated with increased odds of dental caries experience when keeping other variables in the model constant. The association of the oral hygiene practice and sugar consumption was no longer present after the statistical adjustment. However, people who reported cleaning their teeth twice or more per day were those with a higher dental caries experience. This might be explained by the fact that those who already have problem tend to perceive severity of the disease and clean their teeth more (46), but do not appear to be using fluoride toothpaste (47). Khat chewing has been suggested to be associated with some oral conditions including periodontal diseases, attrition of the tooth surface and tooth discolouration, oral cancer and other mucosal diseases. According to Al-Maweri (2018), Khat itself is not cariogenic. However, it has a dehydrating effect on the oral mucosa and a bitter taste. Consequently, Khat chewers tend to consume a large quantity of non-alcoholic fluids, such as carbonated soft drinks, water, and coffee (usually sweetened). Some also supplement the leaves with refined sugar and it also increases the tendency to tobacco smoking (38). A cohort study of 98 Yemeni Khat chewers and 101 non-chewers, aged 18–35 years with early occlusal caries suggested a higher risk of dental caries progression in low-income Khat chewers as compared to the non-chewers, although the study follow-up was short (48).

Whilst dental attendance was generally uncommon, it was notable in those with dental caries experience in our study, only just over one-third had attended a dental service. However, those who had been to the service had seven times the odds of dental caries experience than those who never did. This might suggest that dental visit was perceived need driven and given the level of untreated diseases, care was probably limited to the offending lesion. In this regard, the main reasons for not attending dental services are generally multifactorial (39), and it can also be highlighted by the barriers of access related to the direct and indirect costs. A study of Jordanian adults on factors influencing access to dental care also reported the cost of treatment and perceived lack of treatment need, following lack of time as main reasons for not attending a dental care (49). However, our study participants did not highlight lack of time as a reason, but mainly distance to the dental service and cost of treatments. Another study among adult city-dwellers in Burkina Faso also highlighted cost of dental treatment as the main barrier to dental visits (50). Dental treatment is known to expose households to unpredictable and significant financial costs; recent research has shown, in low income households the larger portion of their disposable income could be used for dental treatment mainly in out-of-pocket payment situations (51). This could also be the case in Ethiopia, as out-of-pocket payment is the main method of funding healthcare (52).

According to our findings, half of the people with dental caries experience had missing teeth due to caries, and less than one percent had dental fillings. This indicates that tooth extraction is the most widely used treatment modality for dental caries in the area. This can be explained by late presentation with

disease, due to challenges in access to care resulting in limited choice of treatment. However, socioeconomic conditions can also determine the access to preventive and restorative dental treatments (53), in addition to the inequity of healthcare services which is a challenge in most developing countries. However, the use of primary care services helped most industrialized countries to achieve greater equity so that people with greater health needs can get better access to services (54), albeit with less regularity. Reviews of oral health in the African region also suggested those challenges can be addressed by creating universal and equitable access to quality, affordable and appropriate oral health services (55).

This research provides important insights to dental caries experience in Ethiopia and provides pilot data to inform a nationally representative survey of oral health. This will help to inform appropriate workforce capacity building, through modelling future scenarios for dental service provision. It will be important to develop research informed feasible ways of addressing their oral healthcare needs of urban and rural populations to inform health policy on health promotion and healthcare services. Further research should also investigate oral health in relation to NCDs, together with the possible relationship of Khat and dental caries.

Conclusion

The finding suggests that there is a high burden of dental caries amongst adults in the district of Butajira and marked social inequity. Caries experience increases with age and is less prevalent amongst educated and urban populations. Generally, dental attendance is low and there is a high need for dental care. Overall, this implies a clear need of health system strengthening interventions including oral health promotion.

Declarations

Ethical Considerations

Ethical clearance was obtained from King's College London (HR-17/18-6144) and Addis Ababa University (026/18/PSY). Informed consent was obtained from participants.

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing Interests

The authors declare that they have no competing interests.

Consent for publication

Not applicable

Authors' contributions

MJP conceived and designed the study, and led the ASSET project bid (CH and JEG were co-applicants); CH led the ASSET-Ethiopia project and surgical care survey protocol; JEG led the oral/dental health survey; BB and CH contributed to the oral/dental health survey design, and MJP approved it; FE contributed in

the planning and conducting the study; CH overlooked the fieldwork locally, and BB and JEG remotely; BB cleaned and analysed the data, and drafted the paper; JEG, CH and MJP refined the paper. All authors read and have approved the manuscript for submission.

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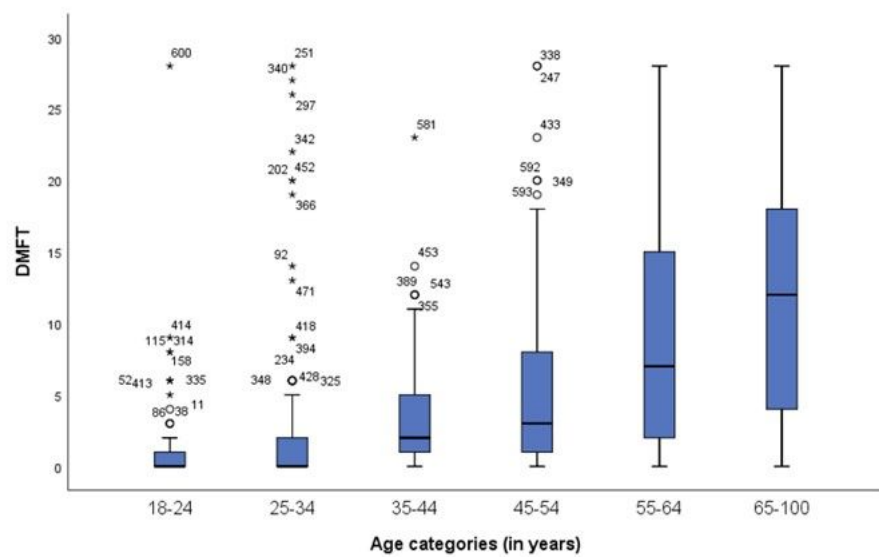
Figures

Figure 1

Progression of dental caries experience (DT: ICDAS 4 and above) across the age categories of adults in Butajira HDSS, South-central Ethiopia