Variation in caries experience and sugar intake among secondary school students in urban and rural Uganda

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The objective was to assess the socio-demographic variation in caries experience and sugar intake among urban (Kampala) and rural (Lira) students in Uganda. In a cross-sectional survey, a total of 1146 adolescents aged between 13 and 19 years (response rate 87%) attending 10 secondary schools, 5 rural and 5 urban, completed questionnaires in respective schools. Clinical examination was conducted among 372 respondents (response rate 90%) from the main survey and dental caries was assessed. The results showed that a total of 80% of the students had DMFT >0. The corresponding rates in Kampala and Lira were 85% and 76% ($P < 0.05$), respectively. The mean DMFT, DT, and MT for the sample were 2.9, 2.5, and 0.5. Adjusted mean DMFT scores were 2.4 in Kampala and 3.3 in Lira ($P < 0.05$). The mean frequency sugar score was 2.6 and sugar consumption was higher in females and in students of highly educated parents compared to their counterparts in the opposite groups. In conclusion, higher mean DMFT scores in urban than in rural areas are often reported from developing countries but this does not seem to apply to the Ugandan areas investigated. Kampala and Lira students were equally exposed to sweets and soft drinks but the differences in sugar consumption between students of higher and lower educated parents were most marked in Lira. □ *Adolescents; caries experience; socio-demographic factors; sugar intake; Uganda*

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A number of scientific reports from economically developed countries have documented a substantial reduction in the prevalence of dental caries between 1986 and 1996 (1–4), with a European average DMFT score of 2.9 (median 2.7) among 12-year-olds (4). In sub-Saharan African countries the caries prevalence of the child and adolescent population has generally remained stable at low levels by international standards (4–7). However, both an increase and a decline seem to have occurred in different parts of Africa (8–10). A summary of the mean DMFT scores from previous studies in Uganda is presented in Table 1 (11–14).

It is evident from available scientific documentation that both between and within regional variation in caries experience exists and that certain sectors of African society experience higher levels of caries than others (7). In developing countries generally, dental caries appears to be more prevalent in children of higher socio-economic status and among urban residents (15). A skewed caries distribution is a typical situation when the overall caries experience is low. Thus, a mean DMFT score for a region or a country may obscure geographic variation (16).

In socio-economically developing countries, changing from a traditional to a more Western-style diet have led to increased sugar consumption from food, beverages, and sweets, particularly among urban dwellers of higher socio-economic status (17, for review, see 18). An increase in the per capita sugar consumption has been reported in a number of developing countries including, Uganda (19). Sugar consumption at the individual level, recognized as one of the main etiological factors of caries (20), might be considered as a proxy measure of socio-economic development. With an average Gross Domestic Product of 6% and industrial production growth rate of 7%, Uganda has been rated as one of the better performing economies in Africa, with sugar as one of the major industrial products (21). Nevertheless, the absolute increase in per capita consumption of sugar from 2.4 kg in 1991 to 7.0 kg in 2000 is still relatively low (19).

Existing caries data from Uganda show that, apart from being scarce, different clinical criteria have been applied; moreover, socio-economic and behavioral factors associated with dental caries have not been investigated. Most studies have examined 12-year-olds, while recent oral health data for older adolescents are not available, yet they constitute a sizeable proportion of the Ugandan population (under 15s constitute about 50% of the Uganda population) (22). Focusing on 13–19 years old adolescents from urban Kampala and rural Lira, this study addressed the following null hypotheses: (a) Students of different socio-economic and demographic status do not differ regarding caries experience and frequency of sugar intake. (b) The distribution of caries lesions does not differ according to tooth type among 13–19 years old secondary school students.

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Table 1. Summary of the mean DMFT scores according to age groups and area of study from previous surveys in Uganda

Reference	Year	Fluoride mg/L	Location	Age (years)	*n*	DMFT (mean)
Moller et al. (11)	1966	0.11–3.0	Rural and urban	10–14	380	0.2
Moller et al. (11)	1966	0.11–3.0	Rural and urban	15–19	256	0.3
Jensen et al. (12)	1972	0.3	Urban	13–15	127	2.4*
Tirwomwe et al. (13)	1987	–	Rural and urban	12	540	1.9*
Tirwomwe et al. (13)	1987	–	Rural and urban	12	540	0.5
Rwenyonyi et al. (14)	1996/7	0.5	Rural	10–14	163	0.2
Rwenyonyi et al. (14)	1996/7	2.5	Rural	10–14	318	0.4

* Including enamel lesions.

Materials and methods

Study population and sampling procedures

The study population comprised students attending public secondary schools in Kampala (0.3 mg fluoride/L) and Lira (0.1 to 1.2 mg fluoride/L). Kampala, the capital city, accounts for nearly one half (41%) of all urban residents in Uganda (22). Lira district is typically rural and situated approximately 350 km north of Kampala. Although the proportion of the urban–rural population in Uganda is 1:5, approximately 80% of all the secondary schools are located in urban areas. There was therefore no strict justification for a proportional sampling of students from the two areas to reflect the urban–rural population ratio.

The STATA statistical program was used to estimate the minimum sample size, allowing for the design factor, the assumed caries proportion in the Ugandan population, and the required precision. A total of 20 schools were listed in Lira and 10 considered for sampling, the inclusion criteria being schools with at least 250 students and placed at least 10 km from Lira town centre. In Kampala, 30 schools within a radius of 10 km from the city centre (main Post Office building) were considered for sampling. A total of 10 secondary schools (5 from Kampala and 5 from Lira) were then selected by simple random sampling. A total of 1146 out of 1324 eligible students, 52% urban, mean age 15.8 (±1.6, range 13–19), response rate 87%, completed structured questionnaires in the autumn of 2001. A subsample for the follow-up survey and the clinical examination was selected by systematic random sampling from a list of the participants of the main survey. The follow-up survey was conducted three months after the main survey. A total of 372 students out of 415 sampled, 48% urban, mean age 16.3 (±1.7), response rate 90%, completed a short questionnaire and were examined for dental caries. Absenteeism from school was the main reason for the non-response, 13% in the main and 10% in the follow-up survey. Overall, the response rate was better in the follow-up survey, possibly because of the incentive of a free toothbrush.

Written informed consent to participate in the study was obtained from the students' parents/guardians. Ethical clearance to conduct the study was granted by the Ethics Committee Norway, the Uganda National Council for Science and Technology, the local administration and schools authorities.

Survey instrument

The structured questionnaire was designed and completed in English, the language of instruction in Ugandan secondary schools. The students completed the questionnaires in their respective classrooms under the supervision of trained research assistants and in the absence of the teachers to ensure confidentiality and to reduce response bias. The survey instrument was peer-reviewed for content validity and pilot-tested before being used in the field. The questionnaire of the main survey had 78 questions, assessing socio-demographic characteristics and a number of variables related to general health and oral health issues. The survey instrument of the follow-up study comprised 32 questions on socio-demographic characteristics and the frequency of sugar intake.

Social and demographic characteristics

Socio-demographic characteristics were assessed in terms of *Gender* 1 = male and 2 = female; *Place of school residence* 1 = Kampala (urban) and 2 = Lira (rural); *Place of residence where raised* 1 = urban and 2 = rural; *Age* 1 = 13–15 years and 2 = 16–19 years. *Father's and mother's highest level of education* were assessed on scales ranging from 1 = 'he/she did not go to school' to 5 = 'university'. Two dummy variables were constructed yielding the categories 0 = 'lower education' (including no education/primary school and adult education) and 1 = 'higher education' (including secondary school, college, university) and added into a sum score of *Parental education* yielding the categories 0 = low, 1 = medium, 2 = high.

Sugar intake

The frequency of sugar intake was assessed using a formative index in terms of an average sum score of 6 items of the intake of sugared snacks and drinks during the previous 3 months as recorded in the main and the follow

up-survey. The items were assessed on a scale in the range 1 = several times a day, 2 = once a day, 3 = 3 to 5 days a week, 4 = seldom, and 5 = never. Before adding the sugar items, each was dichotomized, yielding the categories 1 = taken at least once daily (including the original categories 1 and 2) and 0 = less than once a day (including the original categories 3–5). The sugar score ranged from 0 to 6 with higher scores indicating more frequent intake of sugared foods and beverages. Two additional global measures regarding intake of sugared food and drinks were applied in terms of: 'During the past 3 months—have you taken sugared snacks and drinks on a daily basis? with response alternatives (1) yes, (2) no', and 'During the past 3 months—how often have you taken sugared snacks and drinks on a daily basis?' with response alternatives ranging from (1) several times a day to (5) never.

Dental attendance

Attending a dental clinic for treatment or consultation was assessed by asking: 'If you have attended a dental clinic during the past 2 years, how many times did you attend?' The response alternatives were on a scale in the range 1 = once, 2 = twice, 3 = three times, and 4 = more than three times. For the purpose of analysis, a dummy variable was constructed yielding 1 = once or not at all, 2 = more than once.

Clinical examination

Intra-oral examination was conducted by one trained dentist (I.O.), with an assistant recording the observations. Caries experience was assessed under field conditions using the DMFT index (23). However, in line with previous caries epidemiological studies in Tanzania and Uganda (9, 12, 13), the DMFT index was modified to include enamel lesions, i.e. the D component comprises both enamel and dentine lesions. Students were examined while seated on a chair under natural light. Dental probes and plane mouth mirrors were employed. Caries was recorded as being present when a lesion in a pit/fissure or on a smooth surface had a detectable softened floor, undermined enamel, softened wall or a temporary filling, in addition to sticky enamel lesions. Caries was recorded as present or absent regardless of the number of sites affected in each tooth. A tooth was considered missing if there was a history of extraction due to pain and/or the presence of a cavity. To report the distribution of caries according to tooth type, a sum score for the corresponding tooth type in each jaw, e.g. upper right canine and upper left canine, was constructed yielding 0 = both teeth sound, 1 = at least one tooth carious, and 2 = both teeth carious.

Reproducibility and validity

Approximately 10% ($n = 47$) of the respondents from the follow-up survey had their teeth re-examined clinically for dental caries with enamel lesions after a period of 1 week. The agreement was satisfactory with a Cohen's kappa of 0.82. There was no evidence of systematic error in the recording of dental caries as tested by Wilcoxon test ($P = 0.74$). Cohen's kappa was also calculated for the socio-economic characteristics assessed on both survey occasions with values ranging from 0.61 to 0.91. The sugar frequency sum score reported on both survey occasions correlated moderately ($r_s = 0.50$) ($P < 0.01$). The sugar score was calibrated against global measures of daily sugar consumption ($r_s = 0.42$) ($P < 0.01$), whereas the overall agreement between the two dichotomous variables (cut-off point at $\geq$1 sugary item daily) was 66%. Using the Mann-Whitney U test, the global measure of past use of sugared snacks and drinks differed statistically significantly between caries-free students and those having DMFT >0 (mean values, 2.9 versus 2.5, $P < 0.05$). To obtain information on the content validity of the items considering sugared snacks and drinks, students' interpretation of the term 'sugared snacks and drinks' was identified through an open question. The most frequently mentioned items were in descending order: chocolate/sweets, biscuits and cakes, soft drinks, fruits and ice cream.

Statistical analyses

All variables analysed in this article are restricted to the number of adolescents who participated in both the main and the follow-up study ($n = 372$). The Statistical Package for Social Sciences (SPSS version 10.0) was used for the analysis of data. The significance level was 5%. Cohen's kappa and Wilcoxon signed-rank test were applied to test for reliability of categorical data and systematic errors in the DMFT scores. Non-parametric tests (Mann-Whitney and Kruskal-Wallis) and their corresponding parametric alternatives were used for univariate analyses, whereas multivariate analyses were carried out using General Linear Models (GLM-ANOVA).

Results

Table 2 gives the percentage distribution of participants by age, gender, parents' education, and dental attendance. Of the participants, 16% of Kampala students and 17% of the students in Lira were not lifetime residents in the respective areas. To achieve increased precision, all available data were used in the analysis as a re-analysis of data including only lifetime residents provided findings identical to those presented in this article.

A total of 80% had DMFT >0. The corresponding rates in Kampala and Lira were 85% and 76%, respectively ($P < 0.05$). Direct age-sex standardization accentuated the crude rate difference in caries prevalence between Kampala and Lira (85% and 73%, respectively). The distribution of adolescents according to DMFT score (Fig. 1) was skewed and revealed that a relatively higher proportion of urban students were affected by caries as compared to rural students within the DMFT range of

Table 2. Frequency distribution (%) of study participants according to age, gender, parents' education, and dental attendance in Kampala and Lira

	Kampala $n = 180$ (%)	Lira $n = 192$ (%)	All $n = 372$ (%)
Age			
13–15	110 (61)	63 (33)	173 (47)
16–19	70 (39)	129 (67)**	199 (54)
Gender			
Male	82 (46)	106 (57)	188 (52)
Female	96 (54)	81 (43)*	177 (49)
Parental education			
Low	37 (21)	68 (35)	105 (28)
Medium	52 (29)	83 (43)	135 (37)
High	89 (50)	41 (21)**	130 (35)
Dental attendance			
Once in 2 years	64 (61)	102 (67)	166 (64)
More than once in 2 years	41 (39)	51 (33)	92 (36)

The totals in the different categories do not add up to 372 because of missing cases.
** $P < 0.01$; * $P < 0.05$.

1–8. Only rural students had DMFT scores greater than 8. The largest contribution to the overall mean DMFT score of 2.9 came from the DT component (84%), whereas only one filled tooth was recorded.

The second molars were the teeth most frequently affected by caries (30%), closely followed by the first molars (20%), whereas the lower anterior teeth were least frequently affected. The lower molars were more frequently affected compared to their upper counterparts. Less than 5% of the anterior teeth were affected by caries, with the highest proportion recorded for the maxillary central incisors (Fig. 2).

In the bivariate analysis, the mean DMFT scores did not vary significantly with school area, gender, age, or parental education ($P > 0.05$). Students who reported dental attendance once had lower mean DMFT scores than their counterparts reporting more frequent visits (2.8 versus 3.5, $P < 0.05$). Multivariate analyses revealed higher adjusted mean DMFT scores in Lira than in Kampala (3.3 versus 2.4, $P < 0.05$) (Table 3). The relationship between DMFT scores and dental attendance remained statistically significant after adjusting for school area, gender, age, and education ($P < 0.05$).

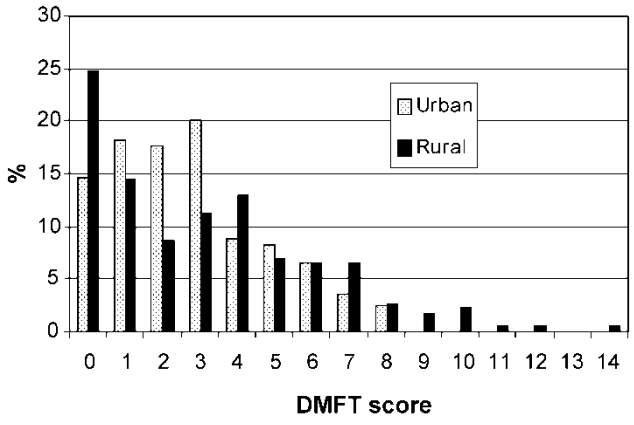

Fig. 1. The percentage distribution of urban ($n = 179$) and rural ($n = 188$) adolescents according to DMFT scores.

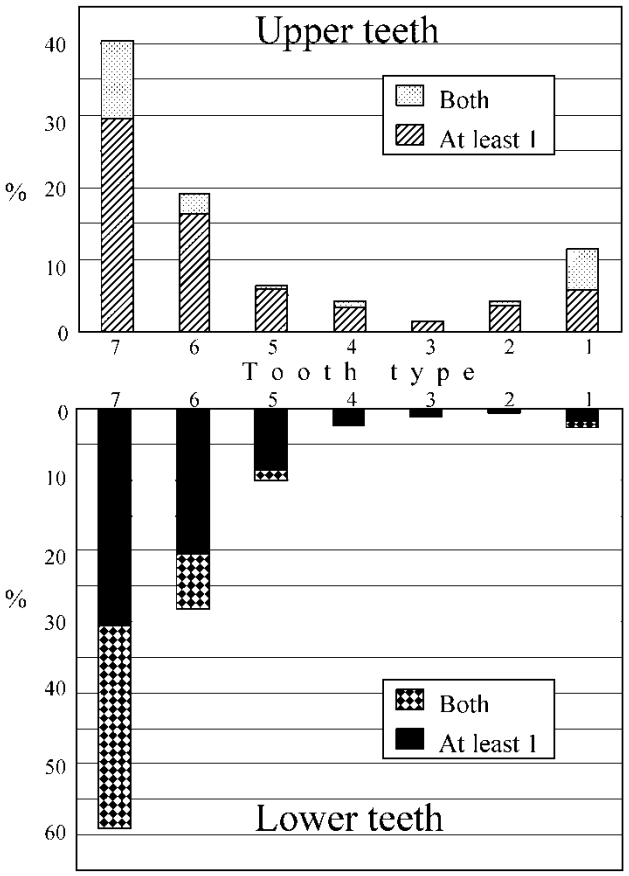

Fig. 2. The distribution of caries according to tooth type with at least one and/or both of the corresponding tooth types from upper and/or lower jaw affected.

The mean sugar frequency score was low, amounting to 2.6 (scale 0 to 6). Bivariate analysis revealed that urban students, females, younger students, and those with parents of higher education reported daily sugar consumption more frequently than their counterparts in the opposite groups ($P < 0.05$). As indicated in Table 3, there were significantly higher adjusted mean sugar frequency scores in females than in males (3.0 versus 2.5), and in students having parents with higher education compared to those having parents with lower education (3.1 versus 2.4). A statistically significant 2-way interaction occurred with respect to survey site by parental education ($F = 4.471$, d.f. = 2, $P < 0.05$). In Lira, the average sugar frequency scores were 2.3, 2.3, and 3.2 ($P < 0.001$) among students with parents of low, medium, and high education, respectively. Corresponding estimates in Kampala were 2.7, 2.9, and 2.8 ($P > 0.05$).

Table 3. Mean DMFT and sugar frequency score (unadjusted and adjusted) by socio-demographic variables

	DMFT		Sugar score	
	n	Mean (95% CI) Adjusted	*n*	Mean (95% CI) Adjusted
School area				
Kampala	104	2.4 (1.7–3.1)	97	2.9 (2.6–3.2)
Lira	145	3.3 (2.7–3.8)*	141	2.7 (2.3–2.9)
Gender				
Male	126	2.5 (2.2–3.4)	122	2.5 (2.6–3.2)
Female	123	3.1 (2.5–3.7)	116	3.0 (2.7–3.3)*
Age				
13–15 years	112	2.8 (2.2–3.4)	108	2.9 (2.6–3.2)
16–19 years	137	2.9 (2.3–3.5)	130	2.6 (2.3–2.9)
Education				
Low	69	3.0 (2.2–3.7)	67	2.4 (2.1–2.8)
Medium	86	2.8 (2.1–3.5)	79	2.9 (2.5–3.2)
High	94	2.8 (2.2–3.4)	92	3.1 (2.8–3.4)*
Dental care				
Once	160	2.4 (1.9–2.9)	154	2.7 (2.5–2.9)
>Once	89	3.3 (2.6–3.9)*	89	2.8 (2.5–3.1)

** $P < 0.001$; * $P < 0.05$.

Discussion

The prevalence of dental caries recorded (mean DMFT scores of 2.9) is higher than those reported among subjects of similar ages from different regions of Uganda (12, 13) (see Table 1) and Tanzania (9). Figure 3 in the Tanzanian study (9) provides evidence of a mean D_2MFT score of 2.4 (where D_2 includes enamel caries). Inclusion of enamel lesions makes the present figures non-comparable with those recorded at the cavity level. Great care should also be exercised when comparing the present findings with the 1972 estimates of a mean DMFT of 2.4 provided by Jensen et al. (12) and with the 1987 (13) national average of 1.9 among the 12-year-olds. The age groups considered are not identical. The participants of the present study were slightly older than those previously investigated. Furthermore, the comparisons may be affected by inter-examiner variability as different examiners were involved. This appears to imply that it is difficult to get a clear picture of the caries situation among children and adolescents across time and different regions in East Africa.

Although not statistically significant, the mean DMFT scores increased with increasing age from 2.8 in the 13 to 15-year-olds to 2.9 among the 16 to 19-year-olds, thus corroborating the age effects reported in previous East African studies (9). Decayed teeth accounted for 84% of the DMFT, the missing component was 15.6%, while the filled component was negligible. The high proportion of not restored carious teeth identified in the present study is consistent with the situation seen in most, if not all, developing countries, and gives cause for concern (14, 26).

The caries lesions were not evenly distributed according to tooth types. Molars and premolars were more frequently decayed in the lower than in the upper jaw. The lower second molar was the tooth most frequently affected closely followed by the first molar. These findings are in agreement with previous reports from Africa (14, 24, 25).

Owing to globalization and economic growth, there is a risk of future increase in dental caries in the socio-economically developing countries (15, 26). The well-documented relationship between dental caries and frequent sugar intake was indicated by the present data, however not convincingly, because the observed association was weak and only approached significance. When considering the general population consuming a conventional diet the relationship between diet and caries is difficult to establish due to the many extraneous factors that may act as confounding variables in the statistical analysis (27). In the present study, only the frequency of refined commercial sugar products was included in the questionnaire. No other fermentable carbohydrates or locally available sugary foods were investigated, nor the duration of sugar consumption. Consequently, it can only be speculated as to the possible effect intake of other fermentable carbohydrates may have had on the observed caries experience in the two areas.

Whereas a larger proportion of students in Kampala than in Lira had dental caries, this gradient was the opposite when comparing urban and rural mean DMFT estimates. This result is at variance with those of most other African studies (28, 29). Similar findings have been reported among 12-year-olds from Uganda (13), among pre-school children from South Africa (30) and 12-year-olds from Mexico (31). Although dental caries is dependent on the fluoride content of the drinking water, reliable results can only be based on those individuals who, with reasonable certainty, could be considered continuous residents in the respective areas (11). It should be noted that although the water samples for fluoride content determination in Lira were taken from the school areas studied, the students in the respective schools came from various parts of the district and some even from other districts. Plausible explanations for the urban–rural gradient observed could be that although fluoridated toothpaste has been available for quite some time in East African countries, there has been limited use in the rural areas (32). Fluoridated toothpaste is more readily available and affordable to the urban community. The higher caries experience among frequent attendees compared with those having visited a dentist only once reflects the greater need for dental treatment rather than an unexpected response to this treatment.

The higher prevalence of dental caries among urban than rural schoolchildren that has been reported in several African studies has been ascribed to the availability of sugar and sweets in the towns (15). The present study does not support this assumption, since no significant difference occurred between urban and rural school students with respect to self-reported sugar consumption. Nevertheless, consistent with findings among comparable age groups in other African countries (18, 33), the present study showed

that students of highly educated parents reported daily sugar intake more frequently than did students of lower educated parents. Parental education discriminated between individuals with more or less frequent sugar consumption in Lira, but not in Kampala, suggesting that an urban lifestyle may have been adopted in all educational groups in Kampala. Clearly, the results of the present study indicate a need for health promotion and for strengthening preventive and therapeutic dental services for secondary school children in urban and rural parts of Uganda. This seems to apply equally to urban and rural areas of Uganda, as the higher mean DMFT scores in urban than in rural areas often reported from developing countries do not seem to apply to the Ugandan areas investigated.

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