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Sugar snack consumption, caries experience and dental pain: surveys of 3-5-and 10-14-year-old children in Uganda

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This thesis is dedicated to my parents Mr. and Mrs. Kiwanuka and to my wonderful son Matthew Austin.

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LIST OF ABBREVIATIONS

ECC   Early Childhood Caries

CDC   Centre for Disease Control and Prevention

TPB   Theory of Planned Behaviour

FFQ   Food Frequency Questionnaire

FBC   Food Behaviour Check-list

DMFT   Decayed Missing and Filled Teeth (permanent Dentition)

Dmft   Decayed Missing and Filled Teeth (primary dentition)

WHO   World Health Organization

FDI   Federation Dentaire Internationale

IADR   International Association of Dental Research

GNP   Gross National Product

GDP   Gross Domestic Product

SCT   Social Cognitive Theory

NMES   Non-Milk Extrinsic Sugars

USD   United States Dollar

UPE   Universal Primary Education

BASCD   British Association for the Study of Community Dentistry

LIST OF PAPERS

Paper 1

Kiwanuka SN, Åstrøm AN, Trovik TA. Dental caries experience and its relationship to social and behavioural factors among 3-5-year–old children in Uganda. *International Journal of Paediatric Dentistry* 2004; 14: 336-346

Paper II

Kiwanuka SN, Trovik TA, Åstrøm AN. Reported intake of sugary products in nursery school children and their parents and predictors of similarity in Kampala, Uganda.
Manuscript for submission

Paper III

Åstrøm AN, Kiwanuka SN. Examining intention to control pre-school children's sugar snacking: a study of careers in Uganda. *International Journal of Paediatric Dentistry* 200; 2006;16: 10-18

Paper IV

Kiwanuka SN, Åstrøm AN, Trovik TA. Sugar snack consumption in Ugandan schoolchildren: validity and reliability of a food frequency questionnaire. *Community Dentistry and Oral Epidemiology*; 2005 (in press)

Paper V

Kiwanuka SN, Åstrøm AN. Self-reported dental pain and associated factors in Ugandan schoolchildren. *Norsk Epidemiologi*; 2005;15 (2):175-182

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1. INTRODUCTION

1.1. Conceptualising dental caries in the primary dentition

Early Childhood Caries (ECC), a term suggested at a 1994 Centre for Disease Control and Prevention, CDC, workshop, (1) denotes any form of caries occurring in the primary dentition of infants and youngsters. There is presently no universally accepted criterion for the diagnosis of ECC (1) and those employed have varied across epidemiological surveys (2). In this study, ECC has been defined as the presence of visual caries (at the level of cavitation) on at least one primary tooth of 3-5-year-old Ugandan preschool children. Although Milne's review (1) of the epidemiology of caries in the primary dentition includes various terms, the CDC workshop recommended the use of ECC when describing any form of caries in the primary dentition (3, 4).

1.2. Focus of the present thesis

This thesis concerns socio-economic, behavioural and social psychological correlates of ECC targeting 3-5-year-old Ugandan pre-school children and their carers. Theoretical concepts from the Social Cognitive Theory, SCT, (5) and the Theory of Planned Behaviour, TPB (6) are utilised to identify social psychological predictors of oral health-related behaviours of preschool children. Secondly, this thesis deals with the frequency of sugar consumption; caries experience and reported dental pain of Ugandan primary school children 10-14-years of age. Specifically, the following aspects are considered: Socio-demographic correlates of dental caries and sugar consumption of 3-5-year-olds attending nursery schools (paper I); 2) the influence of parents' sugar intake on that of their 3-5-year-old offspring's intake and predictors of similarity in consumption patterns (paper II), 3) prediction of parents' decision to control sugar snacking in pre-school children using the TPB (paper III), 4) validity assessment of a food frequency questionnaire, FFQ, applied to 10-14-year-old primary schoolchildren's sugar consumption and (5) self-reported dental pain and its clinical and socio-demographic correlates in primary school children.

Following a socio-epidemiological/socio-behavioural approach, the present thesis takes into consideration factors in children's structural and social environments that might affect oral health (7, 8). A conceptual model, (Fig 1), developed by Chen and Hunter (9), guides the five

papers. According to this conceptual model, demographic- and socio-economic factors at the environmental level and socio-psychological factors at the individual level affect oral health-related behaviour, which in turn affects oral health status. A child's oral health status is the primary determinant of his or her well-being and oral quality of life. According to this concept, environmental factors ("distal factors") might affect oral health behaviours and oral health status directly or indirectly though more "proximal factors". Socio-economic conditions and oral health behaviours might influence oral quality of life directly or indirectly through clinical measures of oral health status.

Fig. 1. A conceptual model guiding Papers I-V
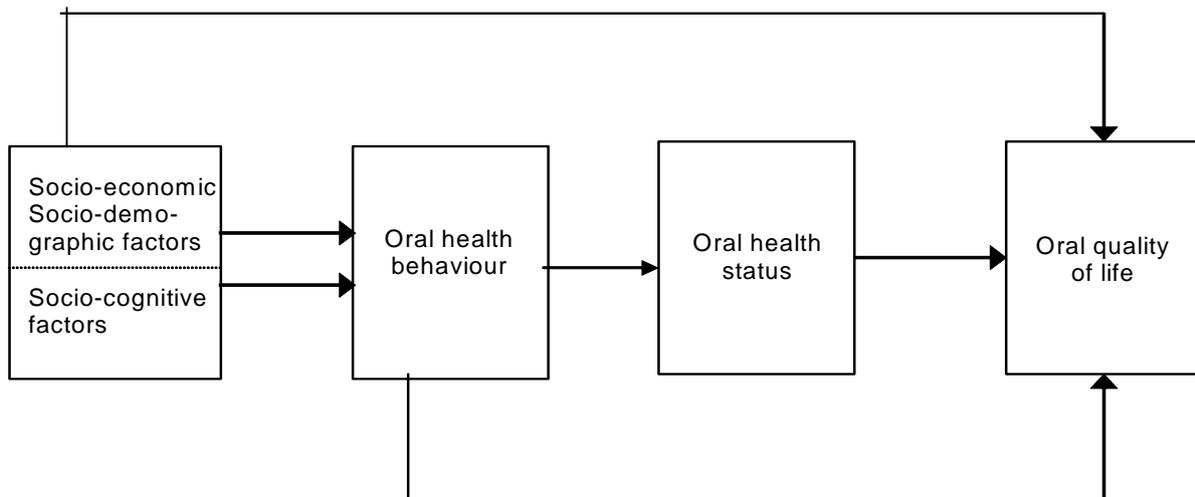
(Chen & Hunter 1996)

The thesis outlined above is justified by the fact that there are very few studies of sub-Saharan African origin that consider the prevalence and distribution of caries in the primary dentition. Studies reporting on the psychological and social impacts of oral health status have mostly been confined to adults (10). Studies from developed countries have shown that the most powerful known single predictor for future caries development is past caries experience (11-13). Thus, the foundation of adult oral health is already laid during the formative preschool years during which a child's dental caries patterns- and caries risk are established. Evidence suggests that behaviours of parents and children that allow the development of feeding

patterns associated with ECC, places them at substantial risk for future caries both in the primary and the permanent dentition (14).

In order to support the planning, implementation and evaluation of early prevention of dental caries in pre-and primary school children, the oral health, oral health-related behaviours, attitudes and social conditions of the whole family should be of concern. This justifies the need for continuous epidemiological surveillance of dental caries and of the socio-psychological impact of this disease in children. Moreover, it justifies efforts to provide theory-based knowledge about the oral health habits and living conditions of preschool children and their carers.

1.3. Trends in the caries disease of children – the situation in developed- and developing countries

Although inter-country differences exist, most dental reports covering 12-yr-olds describe a continuous caries decline across time (15-17). Reports from economically developed countries have also documented a substantial reduction in children's caries prevalence between 1985 and 2000 (7). This decline has been ascribed to a number of public health measures, coupled with changing living conditions, lifestyles and improved self-care practices (18). Changes in diagnostic criteria have also been listed as contributory factors (19). At present, the distribution and severity of dental caries varies in different parts of the world and within the same region or country with average Decayed Missing and Filled teeth, DMFT, scores of 12-year-olds of 3.9, 2.6 and 1.7 in Americas, Europe and Africa, respectively (7).

There are relatively few studies on the caries prevalence in preschool children and the available data are often grouped into broad age categories (20, 21). A review of studies considering the Nordic countries has shown that the caries prevalence and mean decayed, missing and filled teeth, dmft varied from 1% to 71% and from 0.2 to 5.4, respectively (21, 22). According to an extensive review of children's dental caries experience in Europe between 1990 and 1995 (23), caries in the primary teeth of 5-7-year-olds was found to range from 0.8 to 8.5 dmft. Caries in 3-year-old children is mainly found in the maxillary incisors, whereas among 5-year-olds the second molars are the teeth reported with the highest dmft values (24, 25). The international trends in industrialised countries have shown declining dmft scores since 1967, although the absolute level of dmft is high in some countries. Recently, this

favourable trend in the dental caries of the primary dentition seems to have come to a halt (26-28). Moreover, its distribution is skewed and the most under-privileged populations in terms of low socio-economic status and or minority ethnic background bear the main burden of dental caries today (21, 29).

In sub-Saharan Africa, the caries prevalence of the child populations has generally remained stable at low levels by international standards (16, 30-33). However, both an increase and a decline seem to have occurred in different parts of this region (34). According to an overview of the severity of dental caries in the permanent dentition, the DMFT ranged between 0.3 (12-year-olds in Tanzania) to 1.7 (13-14-year-olds in Namibia) (35). Studies from Uganda have shown that the mean DMFT ranges from 0.2 (10-14-year-olds) to 2.9 (13-19-year-olds) (36). Milnes' global review of studies of the epidemiology of dental caries in maxillary anterior primary teeth suggested the highest prevalence to be found in Africa and South-East Asia (1). Table 1 provides an overview of studies dealing with dental caries of the primary dentition (ECC) and its major correlates emanating from African countries. As shown, the prevalence of caries free children (dmft=0) varies across countries. In many instances the prevalence of caries free children is above the goal of the World Health Organization (WHO)/ Federation Dentaire Internationale (FDI) for the year 2000, which was 50%, but clearly below the corresponding goal for developing countries set at 75% caries free children (18).

The goals for oral health to be achieved by the year 2020 recently proposed by WHO in collaboration with the FDI and the International Association for Dental Research (IADR) address important components of the burden of oral diseases, such as dental pain and other dimensions of oral health-related quality of life (34). Several indicators have been developed to assess oral quality of life ranging from single-item global indicators, to complex inventories and scoring systems (37). Little is known, however, when it comes to children's self reported oral health, although oral disorders are widespread and likely to affect quality of life negatively. Few inventories have been developed for assessment of oral quality of life in children (38). Table 2 provides an overview of studies concerned with children's reported dental pain and other oral impacts, emanating from developed and developing countries

Table 1. Studies published between 1991 and 2005 concerned with caries experience in the primary dentition (dmft) and associated risk factors by year, country, area, age and number of study participants in Africa. (Urban (U), Peri-urban (PU) and Rural (R)

Author(s)	Country	Area	Age (yr.)	n	Mean dmft	dmft>0	Risk factors identified
Kerusuo and Honkala 1991(39)	Tanzania	U	3-7	543	2.7	63%	Sweet intake high SES
Ng'ang'a and Valderhaug, 1992 (40)	Kenya	U	6-8	262	1.7	46%	Not reported
Masiga and Holt., 1993(41)	Kenya	U	3-5	446	1.7	45%	Older age,
Raadal et al. 1993 (42)	Sudan	U	4-5	275	1.7	42%	High SES
Matee et al., 1994 (43)	Tanzania	U & R	1-4	2192		1.5-13%	Sleeping with breast Hypoplasia
Mosha et al., 1994 (44)	Tanzania	U	5-6	516	0.7 0.9	28-30%	Urban
Petersen PE , 1996 (45)	Madagascar	U & R	6	1866	4.9	85%	Female, rural
Sathananthan et al 1996 (46)	Zimbabwe	R	5-6	1386	0.6	25.2%	Not using chewing sticks
Khan & Cleaton Jones, 1998 (47)	South Africa	U	3-5	462	2.9	53-63%	Age, parents education
Lallo et al., 1999 (48) [a]	Tz/Uganda/ Mozambique	U, PU & R	5-7	300	2.4	61%	Peri-urban
Frencken et al 1999 (49)	Zimbabwe	U & R	5	1102	1.3	37%	Urban dwellers
Cleaton Jones et al. 2000 (50)	South Africa*	U	2-5	719	0.2-2.2	16%	SES, Racial
Nalweyiso et al., 2000 (51)	Uganda	R	5-7	236	1.5	50%	Not reported
Brindle et al., 2000 (52)	South Africa	R	5-6	100	3.0	64%	Not reported
Ngatia et al, 2001 (53)	Kenya	U	3-5	304	3.0	64%	Age, sugar snack intake [b]
Bajomo et al 2004 (54)	South Africa	R & PU	6	186	2.7	62%	Female, PU
Varenne et al., 2004 (55)	Burkina Faso	U	6	424	0.7	38%	Urban
Kiwanuka et al., 2005 (56)	Uganda	U&PU	3-5	589	2.6	60%	PU, Mothers education, cough syrups, visible plaque

[a] Mean dmft was statistically significantly higher in Tanzania (Tz) and Uganda than in Mozambique
[b] Not statistically significant between the caries free and those with caries
*Article reports on dental caries trends from 1983-1997.Values reported in the table are for 1997

Table 2. Studies on children's self-reported oral impacts emanating from developed and developing countries between 1996 and 2005 by year, country, number of participants and age

Author/year	Country	Sample size/age (yr.)	Dental pain prevalence %	Socio-psychological impacts
Slade/1996 (57)	South Australia	9,690 (5-15)	31.8	Disturbed sleep and schoolwork
Shepherd/1999 (58)	England	589 (8)	47.5	Crying disturbed sleep, play, schoolwork, eating
Naidoo/2001 (59)	South Africa	(8-10)	80 life time 70 past 2mths	Missing school
Okullo et al 2004 (35)	Uganda	1,146 (13-19)	44	Dental care due to pain
Masiga/2004 (41)	Kenya	800 (0-18)	21.6	Dental treatment
Nomura/2004 (60)	South Brazil	191 (12-13)	33.7	Not reported
Gherunpong/2004 (61)	Thailand	1,126 (11-12)	25.1	Disturbed eating, smiling, study and socializing
Kiwanuka and Astrom (62)	Uganda	10-14 yr.	42.1	Caries, subjective oral health indicators, dental attendance
Jamieson/2004 (63)	New-Zealand	204 (6-9)	26.1	Disturbed sleep
Ratnayake/2005 (64)	Sri-Lanka	573 (8)	48.5% (reported by children) 53% (reported by parents)	Ethnicity, parents income & education level, caries
David/2005 (65)	Kerala, India	838 (12)	68.0	Dissatisfaction with oral status and dental appearance

*deciduous dentition

1.4. Nutritional transition in developing countries

Demographic-, socio-economic-and nutritional transitions in populations with low Gross National Products (GNP), have led to changes in lifestyles, which in turn are associated with marked increases in non-communicable diseases (66-68). The nutritional transition is characterised by improvement in dietary variation, but also by a substantial increase in consumption of commercialised sugar products (69, 70). In the absence of effective preventive measures, dental caries is anticipated to take a turn for the worse, particularly among younger age groups and initially more seriously in the affluent urban than in the poor rural populations (7, 18, 34, 71-73).

1.5. Risk indicators for dental caries

In epidemiology, risk is the probability that a particular event will occur within a given period of time (74, 75). Longitudinal studies are necessary in order to establish risk factors for dental caries in the primary and permanent dentition, whereas a cross sectional study can only provide evidence of risk indicators or predictors of this disease (75, 76). A risk indicator may be a probable risk factor, but caution is needed if cross-sectional relationships are deceptive. In this thesis, the concept of risk indicators is used since risk is imputed from cross-sectional data. This is so, although some of the correlates of ECC examined, such as sugar consumption, has been verified as an etiologic factor of dental caries for decades (75).

1.5.1. Oral health related behaviours

Breast and bottle feeding habits have featured as caries risk factors in several studies emanating from both developed and developing countries (3, 76, 77). It has been suggested that putting a child to bed with a bottle is a widespread behaviour, however with prevalence far in excess of that of ECC (3, 76). Children who receive sweetened pacifiers and bottles containing sweetened milk or other sweet drinks have shown a higher prevalence of caries than those whose bottles contain only water (3). Sugar misuse, in particular a high frequency of consumption of sugared beverages has been reported as a risk indicator and a confirmed risk factor in many caries risk assessment models in very young children (76, 77). Some studies have provided evidence of only weak relationships between intake of sugared snacks and dental caries (78, 79). Gibson and Williams (78) suggest that the apparent weak relationship found in studies from developed countries is due to the widespread use of sugar with other factors becoming more important discriminators of dental caries.

A balance between bad habits by way of having a highly cariogenic diet and good habits by way of maintaining good plaque control has appeared to be of importance in the development of dental caries (80). Recently, the importance of an existing maximum level of consumption of free sugars has been emphasised because when the level is less than 15 kg/person/year, the level of dental caries is low (71). The optimal exposure to fluoride may, however, increase the safe level of consumption of sugars to 20 kg/year (81). It has also been recommended that the frequency of intake of free sugars is limited to four times per day because above this frequency the amounts of sugars consumed tends to exceed 15 kg/year and higher levels of caries occur (81). Sheiham recommended that in the presence of fluoride a safe intake of

sugars would be up to 15 kg/person /year and in the absence of fluoride up to 10 kg/person/year (82).

1.5.2. Evidence on the relationship between sugar intake and dental caries
Sugars as the principle dietary substrate that drives the caries process has yet to be scientifically challenged (83). The term *sugars* include glucose, fructose, sucrose, maltose and lactose (84). The term *sugar* refers to sucrose. Most reports dealing with the relationship between sugar intake and dental caries refer to extrinsic sugars, which are not located within the cellular structure of food. In the present thesis, non-milk extrinsic sugars (NMES) have been focussed on, which are sugars found in confectionery, soft drinks, cakes, biscuits and table sugar (71). There is overwhelming evidence that both the amount and frequency of consumption of fermentable carbohydrates are associated with the development of dental caries (83, 85, 86).

Studies where the population itself is the unit of analysis have compared sugar intake and dental caries between countries. Sreebny (87) correlated the dental caries experience of 12-year-olds to sugar supply data of 47 countries and observed a significant correlation (r=0.7), indicating that 52% of the variation in caries levels could be explained by the per capita availability of sugars. A later analysis of Woodward and Walker (88), focusing on DMFT in 12-year-olds from 90 nations, did find a significant association between per capita sugar availability when all the developed and developing countries were included in the analysis. Downer (89) reported a strong positive relationship over time (50 years) between caries experience in 5-and 12-year-olds and the availability of sucrose in UK. Ecological designs have been criticised on the grounds of ecological fallacy, that is, when a population is the unit of study those with the outcome may not necessarily be the same people who received the exposure.

Evidence for a link between sugar intake and caries has also come from observations of groups of people that habitually consume either high or low levels of sugars (90-92). As populations move away from their traditional food habits and adopt a more Westernised diet high in free sugars, a marked increase in caries has been observed, for example among the inhabitants of the Island of Tristan da Cunha (93).

Numerous observational studies of cross-sectional design comparing sugar intake (amount and frequency) with dental caries in the permanent dentition have been summarised by Rugg Gunn (94). He provided evidence of a positive relationship between intake and dental caries in many but not all of the studies investigated. Stronger evidence of such a relationship comes from studies using *longitudinal designs* (95-98).

Human intervention studies in which diet is altered and caries is monitored over a period of time give the most accurate assessment of the effect of diet on caries. The Vipeholm study, (-unethical by current standards) (99) and the Turku sugars study (100) definitely established that the more frequently sugars were consumed, the greater the caries risk.

Recent reviews have argued that because of the widespread use of fluoride in industrialised countries, the relationship between sugars intake and dental caries in children and young adults has weakened. This evidence has called into question the importance of sucrose reduction in the health and food policy of industrialised countries (101). Marthaler (23) concluded from an extensive review of papers published between 1990 and 1995, that in spite of a dramatic reduction in caries due to fluoride exposure, sugars continue to be the main threat to dental health. Burt and Pai (102) came to the same conclusion based on a systematic review of studies conducted between 1980 and 2000. There are other extensive reviews of the same body of literature concluding that non-milk extrinsic sugars, particularly sucrose are the main cause of dental caries (83, 103, 104).

1.5.3. Social and psychological factors

Caries has been considered a social class disease (105). In the developed and increasingly also in developing countries studies have shown that the burden of dental caries and the need for dental care is highest among the poor and disadvantaged populations (7). Links between high caries experience in pre-school children and low maternal education have been reported (21, 106). Low family education has also been identified as a dental caries disease marker in pre-school children from developing countries (47). Other studies from developing countries have documented on an opposite social gradient, with children of higher socio-economic background being those most severely affected by dental caries (35, 47, 107).

Cognitive factors are the intellectual, perceptual and emotional variables that influence health risks either directly through psychosomatic mechanisms or indirectly through health related

behaviours (108). It is the latter indirect route that has been focused on in this thesis through exploration of relationships proposed by socio-cognition models such as the theory of planned behaviour, TPB (Fig. 2) (6) and Bandura's SCT (5).

Fig. 2. Ajzen's theory of planned behaviour (TPB)

EXTERNAL VARIABLES	Belief about outcomes x evaluation	Attitude towards behaviour		
Demographic variables: Age, sex, occupation, SES, religion, education	Normative beliefs x Motivation to comply	Subjective norm	Intention	Behaviour
Personality traits: Extraversion Agreeableness Conscientious-ness Neuroticism Openness	Perceived likelihood of occurrence x Perceived fac./inhib. power	Perceived behavioural control		

Although these models have been used to explain a range of health and oral health-related behaviours (109), there are few studies that apply the models to oral health behaviour with consequences for ECC. With few exceptions, little research has been done outside North America and Europe.

The Theory of Planned Behaviour

Ajzen's (6) TPB is outlined in Fig. 2. As illustrated, the TPB is based on the assumption that the intention leads to enactment of behaviour. Obviously this is not always the case. Factors such as situational constraints and lack of skills contribute to reducing the association between intentions and behaviour. Furthermore, behaviour often tends to develop into habits, which are conducted repeatedly and automatically. As indicated by its name, however, the TPB is

restricted to behaviour which is under at least some volitional control (6). See paper III for a detailed description of the TPB model and its hypotheses.

Parental modelling of children's oral health related behaviour

Social cognitive theory, SCT, (5) explains human behaviour in terms of an interaction between personal factors (including cognitions) and environmental influences. One reason that the SCT considers the environment to be important is that the environment provides role models for the adoption and maintenance of individual behaviour. From the point of view of SCT, overt behaviours of significant others represent important sources of social influence. From observing the behaviours of models (parents, friends etc), not only the performance of the behaviours but also its antecedents (e.g. attitudes) and consequences, the observer forms an idea of how new behaviours are performed. Modelling occurs when the model and another person display similar behaviour. Several characteristics of the role model, such as perceived similarity with the observer, high social competence and power are factors that facilitate modelling of behaviour. Models are also likely to be more influential if they are perceived as warm and supportive. These modelling factors, which characterise many parents, increase the probability that their offspring will pay attention to their behaviour and expect positive consequences from imitating it. Numerous studies, predominately of occidental origin, have provided evidence that parents influence their offspring through modelling concerning a wide range of health related behaviours (106, 110-113).

1.6. Purpose of the study and research questions

This study aimed primarily, through survey research, to investigate the socio-demographic and behavioural distribution of dental caries in 3-5-year-olds (ECC), the influence of parental oral health habits on that of their3-5-year-old offspring and the attitudinal factors underlying parents' decision to control pre-school children's sugar snacking. An additional aim was to assess dental caries in the permanent dentition and self-reported dental pain of 10-14-year-old primary school children. A methodological paper contributes to the thesis by evaluating the validity of a food frequency questionnaire used to assess sugar snacking in children 10-14-years-old.

1.6.1. Research questions

Paper I. Dental caries experience and its relationship to social and behavioural factors among 3-5 year-old-children in Uganda

Focusing on 3-5-year-old children attending nursery school in peri-urban and urban areas of Uganda and their respective parents/caretakers, this study aimed to identify:

- The socio-demographic and behavioural indicators of ECC.
- The socio-demographic variation in the frequency of children's intake of sugared snacks and drinks.

Paper II. Reported intake of sugary products in nursery school children and their parents and predictors of similarity in Kampala, Uganda

- Focusing on children attending nursery school in urban and peri-urban areas of Uganda and their respective parents/caregivers the following hypotheses were tested:
- The frequency of consumption of sugary products as reported by parents is positively associated with the corresponding habit of their 3-5-year-old offspring.
- The consumption of sugary products of the same sex parents is more strongly related to the children's sugar habits than the consumption of the opposite sex parent.

Paper III. Examining intention to control pre-school children's sugar snacking: a study of carers in Uganda

- Focusing on nursery school children in urban and peri-urban areas of Uganda and their respective parents/caregivers the following research questions were examined:
- Do parents' attitudes towards sugar control as defined by the TPB vary according to reported family socio-economic status?
- Using the TPB as a framework what are the attitudinal factors influencing parents' sugar control intentions and the extent to which intake of sugared snacks occur in pre-school children?
- What are the beliefs underlying parents' intention to control child's intake of sugared snacks?

To address the above study objectives data from two field studies are included in this thesis.

Paper IV. Sugar snack consumption in Ugandan schoolchildren: validity and reliability of a food frequency questionnaire

- To assess the reproducibility and relative validity of an eight-item food frequency questionnaire on intake of sugared snacks and drinks among 10-14-year-olds attending primary school. Socio-demographic and clinical dental status correlates of children's sugar intake was also examined.

Paper V. Self –reported dental pain and associated factors in Ugandan schoolchildren

- Focusing 10-14-year–old primary schoolchildren in Kampala, this study aimed to assess the prevalence of dental pain and its association with dental caries experience, socio-demographic characteristics, oral hygiene, dental attendance and self-reported oral health. Socio-demographics as possible effect modifiers of the association between dental caries and dental pain was also investigated.

2. MATERIALS AND METHODS

2.1. Study area

Uganda is a landlocked country located in eastern Africa (population; 27.2 million). More than 50% of the Ugandan population is below the age of 14 years and 35% of its population is living below the poverty line. Uganda has a Gross National Product (GNP) per capita of USD 1,700 and the public expenditure on health as a percentage of GNP was reported to be 1.5% in 2000 (114).

The two surveys presented in this thesis were conducted among children attending nursery- and primary schools in Kampala, the capital city of Uganda (0.3mg fluoride/L) (Fig. 3). Kampala City is located in southern Uganda on the northern shores of Lake Victoria and covers an area of 197 km^2. The city has five administrative divisions; Rubaga, Kawempe, Nakawa; Makindye and Kampala Central. The 2002 Census put the City population at 1.2 million people (49% male, 18% below the age of 5 years) but the City has a daily transient population of about 2.3 million people. According to the Population and Housing Census (115), Kampala's population grew at a rate of 3.9% per annum in the inter-censual period

between 1991 and 2002 (average density: 51 in/ha). A total of 12.2% of the national population is living in urban areas of which 41% is resident in Kampala City alone. A total of 39% of the population of Kampala is unemployed according to Population and Housing Census (116).

Fig. 3. Map of Uganda and Kampala district
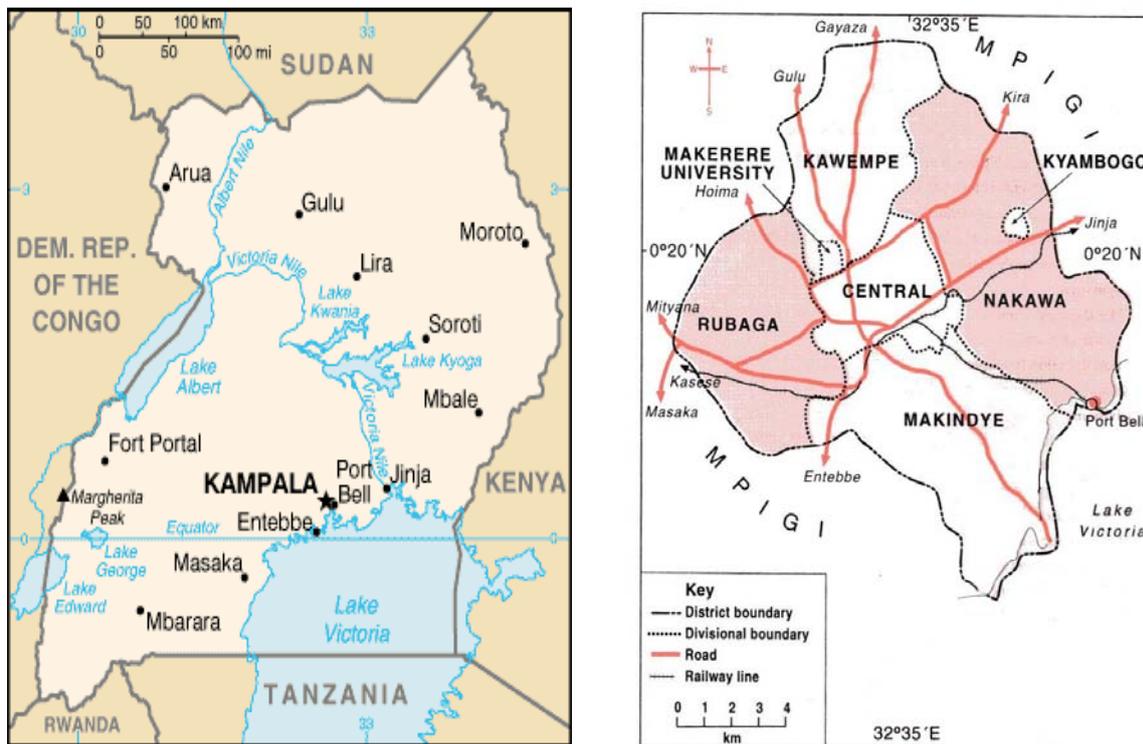
2.2. Selection procedure and study profiles

The present thesis is based on two separate surveys; Survey I-II outlined in Table 3.

2.2.1. Survey I

The material for survey 1, which applies to Paper I, II and III, was collected during July-October 2002. The sample size was estimated to about 600 pre-school children, aged 3-5 years and their parents/caregivers. This sample was achieved using a random one stage cluster sampling procedure, stratified according to study divisions (urban Kampala-Central and peri-urban Nakawa, (Table 4) and with proportionate allocation from each stratum. Nursery school was the primary sampling unit. Kampala-Central (area 14.7km^2) and Nakawa (area 40.7 km^2) (Fig. 3) were purposively selected out of five divisions in Kampala city. A total of 52 and 64

nursery schools were listed in the two selected divisions. Nursery schools with less than 20 children or more than 150 children were not included in the sampling frame. Four schools in Kampala central and five schools in Nakawa were selected by systematic random sampling (for a detailed description see Paper I). All children aged between 3 and 5 years attending the

Table 3. Survey I and Survey II constituting the basis of the five papers presented in the thesis

Paper	Focus	Sample description
I II III	SURVEY I ECC and associated risk factors Parents' and children's oral health behaviour Prediction of parents intention to restrict their children's sugar intake	One stage proportionate cluster, n=618 3-5 years old children Nakawa and Kampala Central, Year 2002
IV V	SURVEY II Validity assessment of children's reported sugar intake Self-reported dental pain	Stratified random sample, n=614 10-14 years old children Kampala-Central, Year 2004

selected schools during the period of data collection and their respective parents /caregivers were invited to participate in the study. A total of 618 of 694 children (89% response rate) eligible children and their caregivers participated. A test- retest involving 56 respondent-child pairs was carried out 4 weeks after the main survey.

Table 4. Total number of subjects eligible for study and participants in Survey I according to strata and schools attended

Division/strata	Nursery school	Number attending school	Response rate n (%)	Children with sibling eliminated *	Participation rate n (%)
Nakawa	Trinity	48	40 (83.3)	1	39 (81.2)
(peri-urban)	Agape	80	71 (88.7)	2	69 (86.2)
	St Stephens	88	83 (94.3)	6	77 (87 5)
	Peak	79	66 (83.5)	2	64 (81.0)
	Sanyu	45	38 (84.4)	2	36 (80.0)
Kampala-Central	Makinnon	69	61 (88.4)	3	58 (84.1)
(urban)	Alpha	82	78 (95.1)	2	76 (92.7)
	Aga Khan	146	130 (89.0)	11	119 (81.5)
	Haggai	57	51 (89.5)	0	51 (89.5)
	Total	694	618 (89.1)	29*	589 (84.9)

In case any child had an eligible sibling in the same school one of them was selected randomly to participate.

2.2.2. Survey II

Within Kampala central 13 out of 25 schools receive government grants under the Universal Primary Education (UPE) Policy [a]. Pupils attending these government-aided primary schools constituted the target population of Survey II since the schools serve people of various socio-economic status around the city.

Standard seven pupils attending 13 government-aided primary schools in Kampala Central were targeted in this study which was conducted during January-March 2004 but two schools were eliminated due to having very small numbers of pupils (n<30). Lists of all children in standard 7 in the 11 schools were obtained from the school authorities. Using a pre-determined sampling fraction, a proportional number of children (every third child from the class lists) was selected to participate (Fig 4, Table 5). Out of a total of 2589 standard seven children, 826 were issued letters (sampling fraction 826/2589) seeking parental consent and 701 signed letters were returned. A total of 614 participated of which 45% were boys (participation rate 74%). A follow-up study was conducted four weeks after completion of the main data collection. Participants attending four conveniently selected schools (n= 394) volunteered to keep food behaviour checklists (FBC) for a total of five days. These food records were collected at the school every evening by the main researcher and assistants, with the help of the class teachers. A total of 342 children (86.8%) completed the required five-day food records. Those who were above 15-years of age (n=17) were excluded from the analyses.

The participation rate for the follow-up study was 82.4% (44.6% boys). A test-retest exercise involving children from one school (n= 48) was carried out one week after the main questionnaire.

2.3. Survey instrument

2.3.1. Survey I

Interview: Sixty-eight structured questions were administered by 3 trained research assistants and completed by the caregivers in face to face interviews. The interview was carried out in

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[a] All primary schools in Uganda are registered with the Ministry of education. In 1996, the policy of Universal Primary Education (UPE) which allows four children per family to obtain free primary education in the government aided primary schools (this was amended in 2000 to allow for all children of school going age). The policy was aimed at reducing disparities in education and its introduction lead to an increase in primary school enrolment from 2.5 million in 1996 to 6.8 million in 2002. It is estimated that 90% of all children of school going age are presently enrolled in government aided and private primary schools all over the country (117).

Fig. 4. Selection procedure and Survey II profile
(the individual pupil was the sampling unit)

Total number of standard seven children attending 11 government schools in Kampala central
2589

Number of children selected to participate
826 (100%)

Children who did not return consent forms sent to parents
125(15%)

Children who refused to be examined
20(2%)

Number of children above 15 years of age excluded from analyses
67(8%)

Participation rate for FFQ / clinical examination - children 10-14 yr.
614 (74%)

Test-retest participants
48 (7%)

Children selected to participate in five-day FBC
394(64%)

Children who completed five-day FBC
342(86.8%)

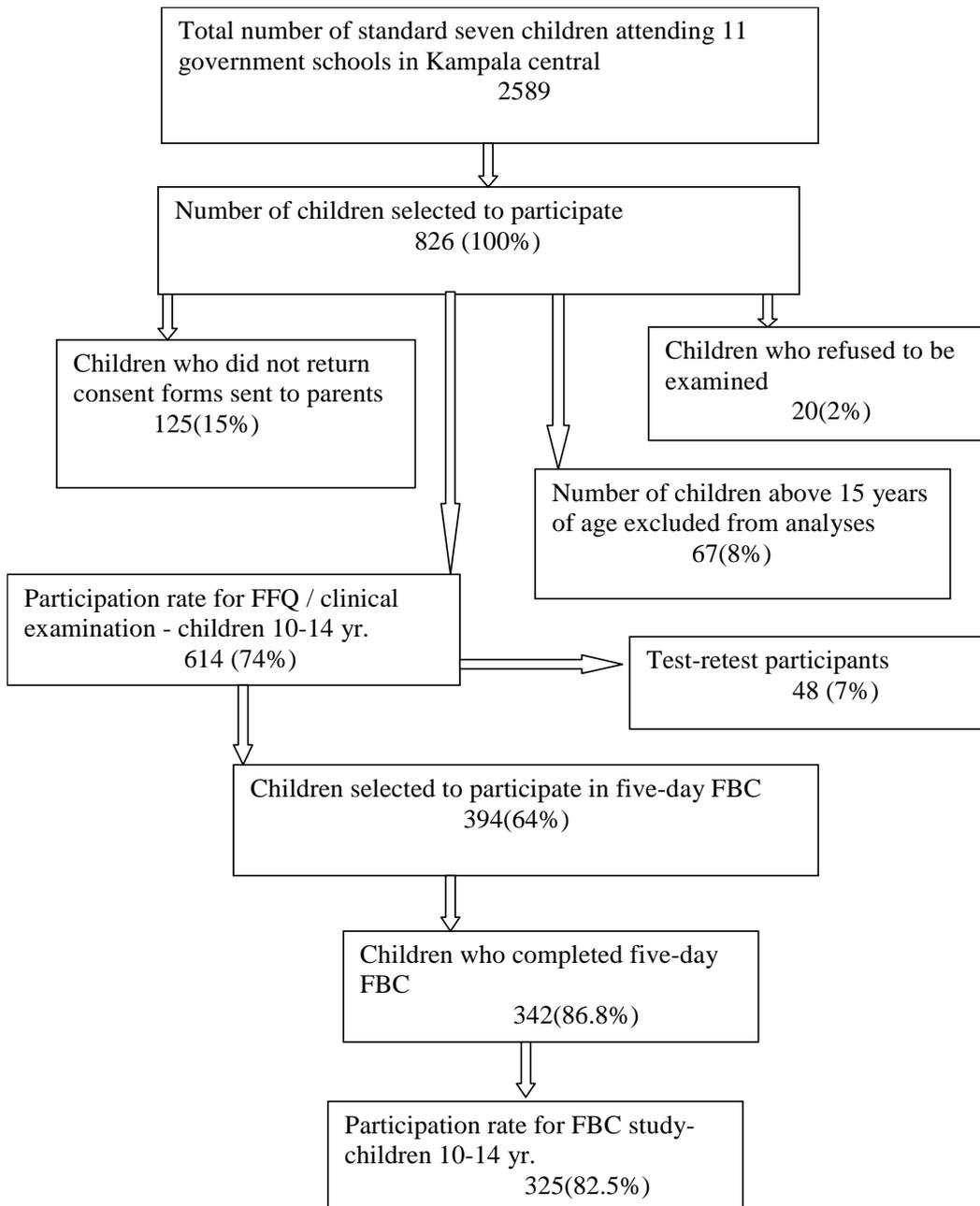Participation rate for FBC study- children 10-14 yr.
325(82.5%)

Table 5. Number of subjects eligible for study and number of participants of Survey II in each selected primary school

Primary schools in Kampala city	Number of children eligible	No. children selected n	Participants per school (returned signed letters) n (%)
Nakasero	395	130	101 (77.7)
Kitante	387	116	85 (73.3)
Buganda Road	343	108	95 (88.0)
Bat Valley	418	140	126 (90.0)
Shimoni Dem.	512	151	139 (92.1)
Old Kampala	117	36	33 (91.7)
Kampala Primary	61	20	18 (90.0)
Nnabagereka	61	25	20 (80.0)
East Kololo	68	25	18 (72.0)
KCC Kamwokya	62	20	18 (90.0)
Nakivubo	165	55	48 (87.3)
Total	2,589	826	701 (84.9)*

*20 children refused to be examined or were absent on the day of examination and 67 children were above 15-years of age.

English (official language in Uganda). Translation (and back translation) into Luganda, the main local language was necessary for only a few of the participants (details described in Paper I). Information was collected on socio-economic indicators in terms of household assets, parental education, oral hygiene habits and dietary history of the children and the respective caregiver. The questionnaire was pilot tested and adjusted accordingly before being used in the field. For further information about the variables included see Appendix I.

2.3.2. Survey II

Self-administered questionnaires: A guided structured questionnaire, including an eight-item food-frequency questionnaire, was administered by the main researcher with the help of four-trained research assistants. The children were gathered together in a free classroom to fill in the questionnaire which comprised of questions regarding household assets, parental education, dietary history of the children, oral health habits and perceived oral health status. Each question was read out loud while the children filled in their answers under the supervision and guidance of the assistants. The questionnaire was constructed in English, the language of instruction in Ugandan primary schools. Sensitivity to culture and selection of appropriate words were considered. The questionnaire was pilot tested and adjusted accordingly before being used in the field (see Appendix III).

Food behaviour check list (FBC): A simplified 24-hour recall questionnaire in the form of a check-list including the commonly consumed sugar snacks and drinks was completed for 5 consecutive week days (Monday-Friday) by approximately half of the school children from 4 purposively selected schools. It assessed whether or not/ and the number of times a specific sugar item was consumed on the previous day (see Appendix V).

2.4. Clinical examination

One trained and calibrated dentist (SNK) conducted the clinical examinations in both studies under field conditions with one assistant recording the observations. Initially the presence or absence of plaque on the maxillary anterior teeth was recorded. Caries was assessed using the dmft and DMFT indices as described by the WHO (for a detailed description of the clinical examinations in Survey I and II see Papers I and IV, respectively (clinical forms are in Appendix II and IV).

2.5. Characteristics of the data and statistical analysis

Data analysis was carried out using SPSS (versions 10.0, 11.5 and 13.0) and STATA (versions 9.0). Table 6 summarises the main statistical methods that were used for the studies.

2.6. Ethical considerations

Ethical clearance to conduct the studies was granted by the Ethical Committee Norway, The Uganda National Council for Science and Technology and the school authorities. Written informed consent to participate in the studies was obtained from the parents/guardians of the children.

Table 6. Statistical methods used to analyze data included in Paper I-V.

| Statistics and methods used | Papers | | | | |
	I	II	III	IV	V
Chi-square test	+	+	+	+	+
Cohen's Kappa	+	+	+	+	+
Cronbach's Alpha	+			+	
Intra-Class Correlation Coefficient (ICC)	+		+	+	
General Linear Models, GLM (ANOVA)	+				
(ANCOVA)			+		
(MANOVA)			+		
Logistic Regression	+	+			+
Principle Component Analysis (PCA)			+	+	
Spearman Rank Order Correlation Coefficient				+	+
Mc Nemar's Test				+	
Wilcoxon Signed-rank Test	+		+	+	
Paired Sample *t*-test		+			

3. RESULTS

Paper I (Survey I): Dental caries experience and its relationship to social and behavioural factors among 3-5-year-old children in Uganda.

Five–hundred and eighty nine children 3-5-years old participated in the study. The mean dmft scores were 1.7, 2.4 and 3.1 and 42%, 44% and 42% had visible plaque on anterior teeth in the 3, - 4, - and 5 yr. olds, respectively. In Nakawa a total of 64%, 62% and 22% of the subjects had respectively dmft>0, dt>0 and mt>0. The corresponding rates in Kampala-Central were 56%, 55% and 17%. A total of 25% and 33% of 3-, 4-, and 5-yrear-olds, respectively had a dmft>0 in the maxillary central incisors. Attending peri-urban Nakawa schools, having a mother of lower level of education, reporting intake of cough syrup, having visited a dentist and scoring positively for plaque were associated with higher odds (OR's 1.6, 1.5, 3.7 and 2.7) for having dmft>0. Almost all children reportedly took milk or tea with sugar on a daily basis in Nakawa and Kampala-Central (97% versus 93%). The overall mean sugar frequency score did not vary systematically with age, gender, locality of school, cough syrup consumption and dental attendance. Statistically significant higher sugar frequency scores were found among children with mothers of lower education and positive plaque scores than among their counterparts in the opposite groups.

Paper II (Survey I): Reported intake of sugary products in nursery school children and their parents and predictors of similarity in Kampala, Uganda.

Children's average intake of sugared tea/milk, sweets and cakes was statistically significantly higher than the corresponding intake of their parents. The children's mean sugar score was significantly higher than that of their parents, 10.61(SD=2.32) as compared to 8.2(SD=1.77) (p<0.001). With regard to tea/milk, a majority of the mothers and fathers (64% and 61%) reported high intake frequency for themselves as well as their child. The opposite was the case for soft drinks; 74% and 72% respectively reported low frequency intake for both parent and child. Being a parent with high sugar score for tea/milk, soft drinks and sweets was associated with higher odds of having a child with higher sugar score on those specific items. Being a mother with high sugar sum score was associated with higher odds of having a child with higher sugar score (OR= 3,3, 95% CI 2.1-5.3). The odds for having a child taking sugared items as often or as rarely as the parents themselves was doubled for 5-year-olds compared to 3-year-olds. Families in roomy households nearly doubled their odds for having

similar sugar consumption (high or low) in parent and child compared to families in crowded households.

Paper III (Survey I): Examining intention to control preschool children's sugar snacking: a study of carers in Uganda.

ANOVAs revealed more positive attitudes and stronger intention to control child's intake of sugared snacks among highly educated parents compared to parents with low level of education. Independent of parental education, parents having children with caries experience (dmft>0) perceived themselves to have less control with child's intake of sugared snacks and drinks The highly educated parents had more positive attitudes and stronger intention to control their child's intake of sugared snacks than the less highly educated parents. Independent of educational level, parents having children with caries perceived less control with child' intake of sugared snacks and perceived them to be more susceptible to tooth decay compared to parents of caries free children. In multiple linear regression, the TPB provided a significant prediction of intention with attitude (b= .16, p<0.001), subjective norms (b=.18, p<0.001) and perceived barriers (b=.11, p=0.01), and significant prediction of reported sugar intake with attitudes (b=-.10, p=0.02) and perceived susceptibility (b= 16, p<0.001).

Paper IV (Survey II): Sugar snack consumption in Ugandan schoolchildren: validity and reliability of a food frequency questionnaire

The proportion of children in the main FFQ (n=614) who reported intake of sugared snacks and drunk at least 3 days a week ranged from 57% (chocolate) to 93% (sugared tea). The mean DMFT was 0.98 (SD 1.6 range 0-15) in children 10-14 years of age attending primary school in Kampala city. Cohen's kappa revealed reproducibility scores for sugar items ranging from 0.17 (ice sticks) to 0.55 (biscuits). There were no statistically significant differences observed between the average intakes at test and re-test. There was generally higher intake reported in the FFQ than in the FBC across all sugar items. The crude agreement between students reporting intake 3-5 times per week/less than 3 times per week ranged from 50-55% (i.e. biscuits and chocolate) to 87% (tea). Spearman's correlation coefficients ranged from 0.14 (dessert) to 0.27 (sweets). There was a significant increase in the mean FBC sum scores by increasing quartiles of the FFQ sum score. Gender and age differences were observed with girls and older students reporting higher sum scores on the FFQ. Children's sugar frequency intake was not positively correlated with their DMFT status.

Paper V (Survey II): Self-reported dental pain and associated factors in Ugandan schoolchildren

The crude prevalence of dental caries was 37.9% and 42.1% in boys and girls respectively. Experience with dental pain was reported by 42.1% boys and 52.3% girls. In boys, 47.9% and 35.2% of respectively, 10-12 and 13-14 yr. olds reported dental pain. A total of 84.3% complained of at least one oral problem. Multiple logistic regression analyses revealed that the odds ratio for having experience with dental pain were 2.7, 2.7 and 2.2 if reporting at least two oral problems, being dissatisfied with dental appearance and having visited a dentist twice during the previous 3 years. Frequency of dental visiting showed a direct relationship with reported dental pain with OR's of 1.9 and 2.2 for children confirming dental visits once and twice during the previous 3 years, respectively. A similar relationship was shown between dental caries and reported pain with those having 0<DMFT<3 and DMFT>3 being 1.4 and 1.8 times more likely to report dental pain than their caries free counterparts.

4. DISCUSSION

In the following section the results of Paper I-V are discussed briefly in light of the stated aims and in terms of their implications for oral health promotion and dental care. A more detailed discussion of the results is found in the individual papers included in this thesis. As a prelude to the discussion of the main findings, some methodological issues are considered. The thesis is concluded with a summary and some final remarks.

4.1. Methodological part

The data utilised in this thesis was collected by standard sample survey method. By definition sample surveys are designed to provide estimates of the characteristics of a defined population (118). In this thesis one study population consisted of 3-5-year-old children attending nursery schools in Kampala-Central and Nakawa and their carers. The second study population consisted of 10-14-year-old children attending primary school in Kampala city. The main strength of the present study, as one of the advantages of a sample survey approach, is that it yields information on many variables of a large number of subjects at a relatively low cost (118). It might however be subject to various sources of error, which might threaten the

validity of the results and the conclusions provided (119). The methodological problems associated with the present approach are discussed in detail in the separate papers. Some of them are discussed below.

4.1.1. Reliability

Reliability is concerned with the degree of consistency or accuracy with which an instrument measures an attribute (120). An instrument is recognised to be reliable when it maximises the true component and minimises the error component of a score. The stability aspect of reliability (precision) can be assessed by comparing the same measure for the same sample at two or several points in time and then translating it into convenient statistics (121). A test-retest approach was applied in both surveys. In Survey I and Survey II, a Cohen's kappa of 0.84 and 0.75 was obtained for dental caries, which represents perfect and substantial agreement, respectively, according to Landis and Koch (122). Moderate to perfect agreement was achieved for the socio-demographic variables assessed in Survey I, with kappa values ranging from 0.66-0.85 (Paper I, II, III). Moreover, a moderately strong Intra-Class Correlation coefficient (ICC=0.49) was obtained with respect to the sugar frequency sum score (a continuous variable) (Paper I). Fair and moderate reproducibility scores were established for the sugar items utilised in Survey II with Cohen's kappa ranging from 0.17 (ice-sticks) to 0.55 (biscuits) (Paper IV). Spearman's correlation coefficient for the other questionnaire variables utilised in Survey II ranged from 0.38 (dental pain) to 0.84 (dental attendance) (Paper V).

Internal consistency reliability was assessed using Cronbach's alpha (123). Internal consistency concerns the fact that items in a scale should be highly correlated if the scale is to be reliable. However, since the coefficient alpha is a function of the number of items comprising a scale there might be problem with its use as a measure of consistency. According to McDowell and Newell (121), alpha coefficients above 0.80 are exemplary, in the range from 0.70 to 0.79 extensive, whereas coefficients in the range 0.60-0.69 indicate only moderate internal consistency. In Survey I, the internal consistency reliability for attitudes and subjective norms were moderate with Cronbach's alpha of 0.45 and 0.53, respectively. Cronbach's alpha for the sugar frequency scores obtained by food frequency questionnaires (FFQ) and food behaviour checklist (FBC) were 0.69 and 0.70 (Paper IV).

4.1.2. Validity

Internal validity deals with the question whether a true measure of the parameters is obtained for the study subjects. External validity relates to whether it is permissible to generalise findings from the sample to a wider population (118).

Internal validity

A measure is said to be valid if it measures what it claims to measure (121). In spite of obtaining acceptable reliability for the clinical variables, the possibility that dental caries has been mis-classified or under-reported cannot be ruled out. A 100% correct diagnosis requires a sophisticated clinical set-up with X- ray units, optimal cleaning and drying of teeth, adequate light etc. The present studies were conducted under field conditions and without X-rays it is impossible to detect approximal non-cavitated (enamel) lesions. Studies from the Nordic countries have confirmed that non-cavitated lesions constitute a substantial part of the caries burden in children (21). In order to standardise the conditions, a calibration exercise was carried out prior to the onset of the data collection according to guidelines published by the British Association of the Study of Community Dentistry BASCD (124). Moreover, for comparability, the rules established for field surveys by the World Health Organisation, WHO, were strictly adhered to (125).

Given the design of the surveys and the reliance on self-reports to assess oral health-related behaviours, attitudes and experience with dental pain, respondents' interpretation of the questionnaires and their ability to recall past events might have influenced the validity of their answers. Retrospective studies always contain some limitations and data obtained through self-reports cannot be verified independently. They are prone to recall bias. Social desirability is a threat to construct validity (i.e. the degree to which an instrument measures the construct under investigation) which has been recognised as the most pervasive problem with respect to self-reported data. It indicates the respondents' tendency to represent a favourable image of him/herself. Thus, there is the possibility that socially desired and undesired behaviours have been over- and underestimated both in Survey I and Survey II. This error might have played a bigger role for data generated from interviews with pre-school children's carers (Survey I) than for the data based on anonymous self-administered questionnaires utilised in Survey II. It was observed, for instance, that 98% of the parents confirmed daily tooth brushing on behalf of their children although visible plaque was present on children's maxillary anterior teeth in 43% of those who were clinically examined (Paper I).

It has been recognised that with appropriate questionnaire techniques, valid and reliable information can be obtained from children (126-128). The questionnaires used among 10-14-year-old pupils in Survey II were pre-tested and adjusted accordingly in order to make them socially acceptable. Commonly used sugar items were assessed and simplified terms were used for addressing clinical oral symptoms to ease the completion of the questionnaires. Anonymity was assured and supervision was available to clarify any queries about the questions included.

Any type of validation might be considered construct validation. Construct validity is dependent on theory. The tests of hypotheses derived from the TPB (Paper III), Bandura's social cognitive theory (Paper II) and from the overall conceptual model (Fig. 1) is as much a test of the construct validity of the various concepts as it is a test of the hypotheses derived from those theories and models. In accordance with the conceptual framework (Fig1), caries experience, frequency of sugar consumption and parental attitudes associated with mother's educational level in the expected direction. Evidence that parents' own sugar patterns and their attitudes were significantly associated with their child's oral health related behaviour, harmonises with hypotheses derived from Bandura's SCT and the TPB (5, 6).

Non-response error and external validity
Guidelines have been published for determining the adequacy of response rates in sample surveys (119). Thus, 80% and over is considered to be good, 70-79% acceptable, 55-69% suspect and rates of 55% or less unacceptable. By those standards, the response rates obtained in Survey I and Survey II being 85% and 74% respectively might be considered at least acceptable. These high response rates were probably due to the clear and appropriate information given to the respondents and to the pre-testing exercises. As a prelude to the clinical examinations, a demonstration with a fearless child was performed and an incentive (toothbrush) was given to the child after the examination. Initial differences due to self-selection attrition should make one attentive to the potential presence of a divergence between the targeted parental population and the studied one. A bias towards health conscious participants is a well-known problem in studies where participation is voluntary (119). Lack of information about non-respondents precludes any firm conclusion about selection bias and implies that the results of the present study should be drawn with caution.

It is questionable whether the participants are representative of urban/peri-urban Ugandan children 3-5-years old. There is no data available with respect to nursery school attendance in Kampala-Central and Nakawa and thus there is a possibility that the sample is under-represented with respect to 3-5-year-old children in those areas and biased towards children attending smaller nursery schools (less or equal to 150 children) in the areas. Given the sampling method, the good response rate and the fact that 90% of all children of school going age are now enrolled in private and public schools, the findings of Survey II might be representative for 10-14-year-old children attending public school in urban Uganda (117, 129).

4.1.3. Sampling error

A proportionate stratified one-stage cluster sample was applied in Survey I with nursery schools as the primary sampling unit. Whereas this selection procedure materially simplified and cheapened the field work, the one stage cluster design with relatively big clusters (ranging from 39 to 119 children) has a tendency toward increasing the sampling error in terms of a widening of the confidence intervals of estimates. This design implies less precision compared to simple random sampling. Nevertheless, the design utilised yielded the lowest cost for estimates having a specified standard error. Data were transformed to STATA (version 8.0) to allow for stratification and cluster in the study design. The 95% Confidence Intervals, CI's, were adjusted accordingly although the initial results provided by the unadjusted analyses were left essentially unchanged (Paper II, Paper III).

A stratified (schools) simple random sample design was applied in Survey II with students attending primary schools (Form 7) in Kampala-Central as the primary sampling unit. This sample strategy provided a self-weighted sample, implying that each participant had the same probability of being selected into the study. In spite of the large sampling fraction, the finite population correction was not accounted for in the analyses.

4.2. Comments on the main findings

4.2.1. Dental caries and dental pain

The findings presented in Paper I highlight the early onset of dental caries in 3-5-year-old children with caries experience amounting to 64% and 56% in Nakawa and Kampala-Central, respectively. The decayed component (dt) contributed 58% of the dmft scores with a minority

(5.4%) of the children examined having filled teeth (ft). This indicates a high level of unmet normative need for dental care among the children investigated. These findings are in line with others reported among comparable age groups in other developing countries (41, 44, 130). This result reflects a low priority given to the preservation of primary teeth. The present findings clearly demonstrates an increase in pre-school children's caries experience with age, which has also been confirmed in other studies (21, 41, 50, 112, 131, 132). A sex difference was present in peri-urban Nakawa only, with caries experience amounting to 70% and 59% in boys and girls, respectively. A limitation of Survey I is that age of the pre-school children was assessed in years instead of months and the fact that the group of 3-year-olds was smaller (n =. 67)[a] compared to the groups of 4-and 5-year-olds (n=239 and n=280 respectively). This could have masked the prevalence of dental caries in the youngest age group.

Although, the average DMFT was low (0.98, sd=1.6) among the 10-14-year-old primary school children examined in Survey II, untreated caries constituted 95% of the total score. Averages at and below 1.0 DMFT have recently been reported from other countries in sub-Sahara Africa (52, 55, 133). David et al. (65) reported a lower average DMFT of 0.5 in the permanent dentition of 12-year-old school children in Kerala in India. Christensen et al.(134), in another study from India reported a mean DMFT+dmft of 1.6 in 11-13-year-olds in Bhopal. In the present study caries experience increased with age in boys only, amounting to 33% and 43% in 10-12-years-old and 13-14-years-old, respectively. In a previous study of Ugandan adolescents (13-19 yr) Okullo et al. (135) found a mean DMFT of 2.9 (2.4 urban and 3.3 rural) with DT contributing 84% of the total DMFT score.

In Uganda, as in other non-industrialised countries little is known about self-reported oral health status or people's social, behavioural and psychological responses to oral problems. In a study of Astrom and Okullo (136), 28% and 62% of adolescents 13-19-year-olds, were respectively dissatisfied with teeth and had experienced at least one oral impact during the 6 months preceding the survey. Wogelius et al. (137) in a study of Danish 6-8-year-olds found dental pain to be associated with dental fear. In spite of the low mean DMFT observed in the 10-14-year-olds investigated in Survey II, the prevalence of dental pain was considerable (47.6%). Moreover, dental caries experience was one of the strongest correlates of dental pain after controlling for socio-demographic and behavioural factors. The association between dental caries and dental pain is worthy of note, given the high prevalence of untreated caries

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[a] Most children start pre-school at the age of 4-years.

reported in studies covering subjects of broad age groups and from different areas in Uganda (51, 56, 135). Dental pain might be a sizeable problem in Ugandan children and might have substantial psychological and social consequences for children and their guardians.

4.2.2. Socio-economic differentials

Geographical location of the nursery schools (Kampala Central versus Nakawa) and mother's educational level emerged as important risk indicators of pre-school children's dental caries experience. A social gradient with respect to caries experience in the primary dentition has been reported widely in the literature (47, 49, 134). The present finding that 3-5-year-olds with most caries experience had mothers of low education and that regional disparities existed gives cause for concern. Socio-economic differences between Kampala-Central and Nakawa were observed with the highest proportion of parents with children attending nursery schools in Kampala-Central being highly educated. Nevertheless, parents whose children attended nursery schools in Nakawa were 1.6 times more likely to have children with caries experience than their counterparts in Kampala, after accounting for educational differences (Paper I). Apparently, regional differences in children's caries experience did not only reflect variation in parental education. This indicates that social factors related to locality of schools are influential in determining caries experience among 3-5-year-olds. Other investigators have suggested that socio-economic factors may impact more strongly on the caries experience in earlier than in later life (113, 138). Moreover, across countries and oral health systems, the effect of educational background on measures of dental caries has been found to be particularly strong when the disease prevalence is high (7). Okullo et al. (135) found a higher caries prevalence in urban Kampala students (85%) than in students from rural Lira (73%), which might be attributed to a positive relationship between non-communicable diseases generally and urbanization in developing countries (139).

Recent studies have indicated that there are ethnic, social and demographic differences in people's perceived oral health status after controlling for clinical variables (140). This has been confirmed in studies of oral health-related quality of life among adolescents and young adults in East Africa (136, 141). A social gradient in children's response to their dental status (i.e. reported dental pain) could not be verified among 10-14-year-old school children in Paper V. There was, however, indication in the data that the positive association between dental caries and dental pain was stronger in children of high compared to children with low socio-economic background.

The results from Paper I revealed statistically significantly higher mean sugar frequency scores among 3-5-year-old children having mothers with a low education compared to those with mothers of high education. As suggested by the results in Paper III, the most deprived families (in terms of low educational level of parents and a positive caries status of their child), reported higher frequency of sugar consumption on the part of the child than their less deprived counterparts. A similar social gradient was not found with respect to sugar consumption in 10-14-year-olds from Kampala (Paper IV). Okullo et al. (135) provided evidence that students (13-19-year olds) with parents of higher education were more likely to report sugar intake than their counterparts having parents with low education. However, this social gradient was present only in rural Lira, suggesting that an urban lifestyle might have been adopted in all educational groups in Kampala-Central. Results from Paper III provided further evidence supporting the suggestion that parental education might be used as a social marker in caries risk group evaluations, at least among preschool children. This study indicated that the most deprived families showed the least positive attitudes towards controlling their child's sugar snacking, felt most vulnerable with respect to children's tooth decay and had the weakest intention to control sugar snacking in the future.

4.2.3. Behavioural differences

In Paper I, about half of the carers in Kampala-Central and Nakawa confirmed that their 3-5-year-olds' intake was above the median on the sugar frequency score. Moreover, among the 10-14-year-olds, a relatively high overall level of sugar intake was confirmed with a higher intake reported by females than by males.

Many studies of various designs have provided evidence of a positive relationship between intake of (amount and frequency) sugared products and prevalence/incidence of dental caries (87, 89, 102). Absence of a positive relationship between sugar intake and caries as indicated by the results of Paper IV, might be due to widespread use of sugar in 10-14-year-olds, with other factors becoming more important discriminators of dental caries (78). Alternatively, this lack of an association might be attributed to unreliability or misclassification of self–reported sugar intake. Most probably, such misclassification has occurred randomly, since self-reported data were recorded before the clinical examination. Thus, it might have led to an underestimation of the association between sugar intake and caries experience and not to the observation of a spurious relationship. Although the sugar frequency score did not discriminate between 3-5-year-olds with and without dental caries, parents who confirmed use

of cough syrup were more likely to have children with caries experience than those who did not confirm use, a finding that accords with other studies (142-144). Moreover, children who scored positively on plaque on anterior teeth were more likely to have caries than their counterparts without plaque. In younger children, the presence of visible plaque has been recognised as a proxy for oral hygiene and has been shown to be a predictor of dental caries (145, 146). The combination of visible plaque and frequent sugar intake at 3-years of age has been reported to be predictive of children's dental health 3 years later (147). It appeared from our findings that children with poor oral hygiene were also likely to have a higher sugar intake and could therefore be at a higher risk of having dental caries (147, 148).

The majority of preschool children (71%) had never had a single dental visit (Paper I), whereas about half (56%) of the 10–14-year-olds had not visited a dentist during the previous 3 years (Paper V). The finding from Paper I is in accordance with the patterns of dental visits reported among pre-school children elsewhere (148-150). In Survey I, the 3-5-year-old children who had ever visited a dentist were those most likely to have dental caries. Consistently, in Survey II, 10-14-year olds who had visited the dentist were those most likely to report dental pain. Similar relationships have been reported elsewhere (151, 152). This pattern might be attributed to symptomatic dental attendance and need for emergency dental care among Ugandan children rather than an unexpected response to dental treatment. This pattern of relationship between dental attendance and disease is opposite to that observed among pre-school children in industrialized countries (21).

From the point of view of Bandura's SCT (5), overt behaviours of significant others represent important sources of social influence. Within the dental health domain, the mother's impact on preschool children is widely acknowledged (153, 154). Whereas parental modeling has proved to be a powerful means of establishing tooth brushing in preschool children (111), it has rarely been investigated in the context of sugar snacking and not yet in parent-child pairs living in a non-occidental society. The results in Paper II have clearly demonstrated that with respect to sugared tea/milk, soft drinks and sweets, the intake frequency of parents and their 3-5-years-old child was significantly and positively associated. Okada et al. (155), used structural relation analyses and provided evidence that parents' oral health behaviour influenced their 7-12- year-old children with respect to gingival health and dental caries both directly and indirectly through its effect on children's oral health behaviour.

4.2.4. Socio-cognitive predictors

As shown in Paper III, the TPB (6) provided significant prediction of intended sugar restriction in children, with subjective norms, attitudes and perceived behavioural control as predictors in that order. The finding that the effect of subjective norms exceeded that of attitudes runs counter to the results of most TPB food-choice studies (156). However, the relative importance of the TPB components depends upon contextual factors and studies of East African origin have shown that subjective norms tend to be a stronger predictor of behavioural intention than attitudes (156, 157). Compared to the results from other food choice studies (frequency weighted average of 39% in explained variance of intention), the 13% explained variance obtained in Paper III seems rather modest (158). Paper III discusses a number of possible explanations for the low predictive value observed. Nevertheless, omission of important predictor variables in the TPB model has been a common explanation for low predictive power. In their review, Conner and Armitage (159) point to several concepts that could possibly be added to the TPB, such as moral norms, self-identity and perceived risk. In a recent overview article Ajzen (6) points out that the general model might benefit from special adaptation depending on the particular health behaviour in question.

4.2.5. Guidelines for dental health education

Knowledge about the extent and distribution of dental caries and dental pain as provided by Survey I and Survey II clearly suggests a need to strengthen preventive and therapeutic dental services among schoolchildren aged 3-5-and 10-14-years of age in Kampala, Uganda. In view of the relatively scarce resources that are available for dental care in Uganda, emphasis should be put on oral health education and oral health promotion activities and simple procedures for dental treatment. The various risk indicators with respect to children's dental health as identified in Survey I and Survey II, suggest that different policies and methods for oral health promotion should be considered (160). The findings of Paper I-III have implications for dental health education by pointing to the importance of early intervention and by emphasising parents, particularly those of deprived background as targets in strategies for promoting oral health in nursery school children. It is evident, according to the common risk factor approach launched by WHO (161), that positive changes in childhood lifestyle might have long term implications in terms of preventing non-communicable disease including dental caries in adult life (162). Paper I indicates that the source of fermentable sugars in products such as syrups, lozenges and teething jellies should be declared by the food and drug

legislators so that parents and other consumers may be made aware of their caries promoting potential.

The results presented in Paper III have shown that carers from urban and semi-urban areas of Uganda are more likely to make a decision for restricting the sugar intake of pre-school children, not only if they expect it to be associated with advantageous outcomes, but also if they perceive a strong social pressure and to feel in control. According to Bandura (5), perceived control can be enhanced through personal mastery experiences and by setting and achieving sub-goals for instance in terms of providing and choosing sugar free snack-alternatives for children. The access to clean water and time seem to be important factors facilitating parents' decision in this regard. Engineering interventions should focus on external control factors to make sugared snacks less available for children at nursery school as well as in their homes. Finally, but not least important are efforts to create favourable attitudes in terms of reinforcing parents' positive beliefs and in terms of introducing new positive beliefs by emphasising the link between good taste and healthy teeth. Recent studies have shown that the TPB has the potential for being a basis for interventions. It has been emphasised however, that motivational factors might not be enough for behavioural change. For effective dental health education in preschool children, parental control with behaviours associated with caries risk should be considered in addition to pure motivational factors.

4.2.6. Concluding remarks

This study has contributed to knowledge about the dental caries experience, oral hygiene and sugar consumption of 3-5-year-old children schooling in socio-economically different areas of Kampala, Uganda. The present findings indicate that ECC and poor oral hygiene are significant problems and that there is a substantial unmet need for dental care among children in this age group. Thus, starting at an early age most of the caries experience remains untreated. Children from deprived families seemed to be most vulnerable with respect to ECC and tended to have higher levels of behavioural risk indicators, whereas their parents were less motivated than well-off counterparts to control child's excessive sugar intake. Data generated by Survey I strongly indicates that oral health promotion programmes, including proven preventive measures like oral hygiene education, atraumatic restoration techniques and topical fluoride application, should pay attention to the whole family setting, its socio-economic status and parental attitudes towards children's sugar restriction. It should however be noted that fluoridation should be embarked upon only after the fluoride content naturally

available in drinking water and diet has been identified to avoid potential increases in dental fluorosis. Given the costs of dental treatment and its psychological effects on children for instance in terms of dental anxiety, interventional efforts should aim at encouraging parents and children to adopt preventive checkups and monitoring of oral health instead of the existing pattern of symptomatic dental visits reported in this study. Schools based oral health programs which have proved successful in other countries could be adopted in Uganda.

The low average DMFT among 10-14-year-old primary schoolchildren is encouraging but masks the level of caries among affected children, while their level of sugar snack consumption and the prevalence of dental pain observed are matters of concern. Dental pain was most frequent in children having untreated dental caries, being dissatisfied with their oral health in general and among those who attended a dentist most frequently. Socio-dental indicators such as pain, quantifying the extent to which oral conditions are disabling, play an important role in health care planning and evaluation. Alleviating the psychosocial implications of dental pain on children and their families should be a priority aim of health policy makers in Uganda. Along with appropriate use of fluorides, children should have access to preventive and restorative dental care. Affordable treatment by use of professional fluoride application on enamel lesions, fissure sealants and the Atraumatic Restorative Treatment (ART) approach have been suggested and could go a long way towards the level of untreated caries among children thus avoiding subsequent dental pain. It might also reduce treatment costs.

Research tools for dietary assessment in children need to be further developed, tested and validated in the Ugandan context to aid in monitoring dietary behaviour. Diet is a risk factor not only for dental caries but also for other non-communicable diseases such as diabetes and heart disease. Children represent a major focus of dental health research and practice and the key to successful oral care is rooted in childhood; it is therefore the dental health personnel, paediatricians and parents' job to guide and control the acquisition of healthy dietary and oral hygiene habits.

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