# MATERNAL AND CHILD ORAL HEALTH STATUS: INVESTIGATION OF THE EFFECT OF PARITY AND SOCIO-BEHAVIOURAL FACTORS

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## Declaration

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## Dedication

*To all Hausa mothers and children*

**Publications and conference presentations emanating from this thesis**

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## Abstract

**Background:** Reproduction in women is associated with physiologic, metabolic and nutritional changes due to adjustments during pregnancy, breastfeeding and childrearing. These changes are thought to be potentially cumulative when parity is high and may have negative effects on the general health of women. It is likely that maternal oral health is affected as well, as 'a tooth for every child' is a common adage in many cultures. Even so, there is limited information on the relationship between parity and maternal oral health status. The available evidence is largely from European populations. Most research investigated tooth loss in women of fairly low parities and failed to consider caries and periodontal disease or the behaviours that are likely confounders affecting oral health status. Furthermore, there are no studies on the beliefs of high parity mothers regarding parity and tooth loss.

**Aim:** The aim of this study was to determine the relationship between parity level and oral health status in a high parity population. Age, nutritional status, socio-economic status and oral health practices (frequency of consumption of refined sugar and tooth brushing, use of fluoridated toothpaste and number of dental visits) were considered when investigating tooth loss, dental caries and periodontitis levels in Nigerian Hausa mothers. Early childhood caries was evaluated for mother-child dyads. Women participated in focus group discussions to elicit qualitative data used to contextualise the study for the Hausa cultural environment.

**Materials and methods:** This was a cross-sectional study with a mixed methods design. A total of 635 married Hausa women of all parity levels aged 13-80 years and 346 accompanying children aged less than 72 months were recruited. Women with 5 or more children were considered high parity while those with less than 5 children were regarded as low parity.

Information on the socio-demographic status and oral health behaviour/practices of the women was obtained using a structured interviewer-administered questionnaire. A separate questionnaire was used to obtain information from the mother on the child's socio-demographic profile and oral health behavior/practices. The weight and height of the participants were measured to calculate their BMI status ($kg/m^2$). The oral hygiene status of the mothers and their children was assessed using the Simplified Oral Hygiene Index (OHI-S) of Greene and Vermillion. All teeth present in the mouth excluding the third molars were recorded, and all missing teeth were recorded

regardless of the reason for tooth loss. Women's caries status was determined using the Decayed Missing Filled Tooth (DMFT) index. Periodontal status was assessed with a lightweight periodontal probe using the Community Periodontal Index (CPI). Caries in the children was also assessed using the dmft index. Women's beliefs on causes of tooth loss and any link between parity and tooth loss were explored through a qualitative analysis using a grounded theory approach through focus-group discussions with 33 women of differing parities.

Data were analyzed using SPSS (version 16) software for Windows. Analyses included frequencies, cross-tabulations and regressions. Statistical significance was inferred at $p<0.05$. Associations between categorical variables were determined using chi-square tests while those between continuous variables were tested with Student's t-tests and ANOVA. The mean DMFT scores and tooth loss with standard deviation were computed for the different age cohorts, parity levels, parity groups (high and low) and nutritional statuses. Comparisons between parity groups were done using Student's t-tests, while comparisons between age cohorts and nutritional statuses were tested using ANOVA. In addition, the mean number of sextants with CPI scores of 0-3 and 4 was determined for the different age groups, parity levels and nutritional status. Comparisons across age groups, parity levels and nutritional status were done using ANOVA. Linear regression was performed to predict the factors that best contribute to caries, periodontal disease and tooth loss in the women with caries, periodontal disease and tooth loss modeled as dependent variables (each in separate analyses) and socio-demographic variables, oral health behaviour/practices, reproductive parameters and nutritional status as independent variables. Information obtained through focus group discussions on causes of tooth loss, parity and tooth loss were analyzed thematically using ATLAS-ti.

Associations between caries experience in mother-child dyads were tested using Fisher's exact tests. Binary logistic regression was done to predict factors that best contribute to early childhood caries (ECC) in the children.

**Results**: Women in the earlier reproductive stages (18-37 years) characterize the study population (65.1%) with 55.7% of them of low parity. The mean parity (4.33±3.04) was slightly below what is regarded as high parity. There was limited variability in the SES and BMI of the participants. Both measures were associated with age, as older women were typically of middle SES and higher BMI. SES and BMI were not associated with caries experience, periodontal disease or tooth loss.

Hausa women generally had low prevalences of caries, serious periodontal disease and tooth loss, despite their poor oral hygiene and limited use of dental care facilities. A traditional diet that is low in refined sugars, along with good enamel quality, may contribute to this oral health profile.

While tooth loss in the Hausa women was generally low, older and higher parity women experienced significantly more tooth loss. In addition, increased duration of reproduction was significantly related to fewer remaining teeth. The contributory weights of age, duration of reproduction and parity to tooth loss were 13.6%, 1.2% and 1.0%, respectively.

Caries experience in the women was also low, yet higher parity women were found to experience significantly more caries. Women's age contributed 8.5%, while parity accounted for 0.8% of their caries experience.

The prevalence of some level of periodontal disease in the participants was very high. The majority had calculus deposits (code 2), although those with periodontal pockets (codes 3 and 4) were few. Age, level of education and frequency of tooth cleaning were significantly associated with periodontal disease. Notably, parity was not significantly associated with periodontal disease.

The caries frequency (ECC) in the children was very low. Binary logistic regression analysis revealed that only the age of the child was significantly associated with ECC. The mother's caries experience was not related to ECC in the child.

The focus group participants did not associate parity per se with tooth loss, although they believed that *payar baka* (vomiting during childbirth) resulted in loss of teeth. The women perceived other causes of tooth loss to be dirty mouth, tooth worm, ageing and sugar cravings.

**Conclusion:** The cumulative effects of high parity, as observed in older women, were associated with maternal oral health status (caries and tooth loss) in a fairly homogenous sample of Hausa women with low variation in oral hygiene status, diet, oral health practices, SES and BMI. Thus, reproductive history is an important determinant of oral health conditions in Hausa women.

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# Chapter 1

# Introduction

## 1.1 Maternal depletion

Reproduction in females is energy demanding and costly as it involves sustaining pregnancy, breast-feeding, and childcare (Jasienska *et al.*, 2017). Pregnancy and breastfeeding involve nutritional, physiological and metabolic adjustments that can cause permanent changes in the mother's response to stress. This is especially true when parity is high (Jasienska *et al.*, 2017). High parity (over five births) (Simonsen *et al.*, 2005) coupled with short birth intervals adversely affects maternal health as documented by osteomalacia, goiter, anemia, edema, inadequate pregnancy weight gain and premature birth (Jelliffe and Maddocks, 1964; Hobcraft *et al.*, 1983; DaVanzo *et al.*, 1984; King, 2003). A proposed phenomenon of insufficient biological resources for healthy reproduction has been termed Maternal Depletion Syndrome (MDS). The syndrome is described as characteristic of women who are nutritionally stressed and then further compromised by short recovery times between successive pregnancies (King, 2003). The cumulative effect of reproductive demands distinguishes MDS from situations where women experience micronutrient deficiencies during a cycle of pregnancy and lactation.

There are various theories regarding the mechanisms underlying MDS. The most general of these arguments asserts that the physical and caloric demands of repeated pregnancy and lactation, in combination with the physical and caloric stresses of life at a basic subsistence level, leads to MDS (Jelliffe and Maddocks, 1964; Hobcraft *et al.*, 1983). Yet nutritional stress alone may not result in MDS. Behavioural factors, including diversion of time, energy and resources to children (including difficulties with access and utilization of health care) (Russell *et al.*, 2008), are proposed as contributors to MDS.

From an evolutionary life history perspective, MDS entails a cost for a reproductive strategy that was probably the most characteristic and successful human reproductive pattern prior to recent historical times. Genetic variants associated with lower reproductive steroid levels, which enable early first birth and high parity, may have been selectively advantageous for humans in the past, although there appear to be health trade-offs for these reproductive advantages (Jasienska *et al.*, 2017). Low steroid levels later in life are associated with increased risk of cardiovascular disease and osteoporosis (Jasienska *et al*., 2017). These costs for older women may have had less impact on populations with shorter life expectancies, as was generally the case until quite recently.

In contemporary societies, higher parity itself is associated with better maternal condition and lower morbidity in certain poor environments and increased mortality from infectious disease in others (Sonneveldt *et al*., 2013). Conversely, high parity is correlated with higher disease risk and mortality in high-income settings (Jasienska *et al*., 2017).

While the concept of MDS seems, on several levels, to be a logical explanation for maternal morbidity in populations with predominantly high parity families, no laboratory-based animal studies or investigations on human populations have verified cumulative deficiencies due to insufficient recovery of mothers (Winkvist *et al*., 1992). The possibility of maternal depletion from successive pregnancies is clearly a complex issue that requires further investigation (King, 2003). It remains uncertain that MDS is a true biological syndrome, and few studies have actually evaluated populations where high parity is most common. Additionally, focusing solely on high parity is not proving to be informative. A broader understanding of available resources, environmental stresses and the general health of women and their children is needed.

### 1.2 Parity and oral health

One neglected aspect of health and its relationship to parity is the oral health of mothers and their children. Is it possible that the cumulative demands of reproduction may impact negatively on oral health? ‘Gain a child, lose a tooth’, or ‘for every child, a tooth is lost’ are common proverbs in many societies (Christensen *et al*., 1998), but the biological basis of these beliefs is not documented. Pregnancy gingivitis is widespread and attributed to hormonal changes that are described as quickly resolved after the birth (Morelli *et al*., 2018). While tooth loss is not directly associated with pregnancy gingivitis, it is not known whether pregnancy gingivitis triggers a progression toward general gingivitis, periodontitis and subsequent tooth loss in women of high parity with short birth intervals.

Sex differences exist in oral health, especially in caries frequencies and, to a certain extent, tooth loss in many populations. Prehistorically, poorer oral health of women compared to men became a common pattern after the onset and intensification of agriculture (Lukacs, 1990; 1992; Lukacs and Pal, 1993; Lukacs and Largaespada, 2006; Willis and Oxenham, 2013). The development of gender-based divisions of labour, the rise of social stratification and inequality, and substantial increases in population size have been suggested as factors contributing to these health disparities (Cohen and Armelagos, 1984).

Biologically, sex-based differences in oral health are attributed to the role of female sex hormones, pregnancy and reproductive history. Many studies documented that females lose more teeth compared to males of the same socio-economic status, while Rundgren and Osterberg (1987) delved further into the issue and found that Swedish women's parity influenced their oral health.

In addition, aging plays a key role in morbidity, including oral health conditions. It involves lifetime exposures to disease determinants, the cumulative effects of various conditions, and age-related biological changes that heighten susceptibility to diseases (López *et al*., 2017). Aging is linked to high parity, especially in developing countries where the duration of reproduction many extend across decades. Thus, a complex relationship exists between aging and parity in many populations.

Research on parity and oral health can be approached by examining the relationship between parity and caries, periodontitis and tooth loss, as presented in the following sections.

### *1.2.1 Parity and caries*

A broad array of prehistoric populations demonstrates prevalence of dental caries that varied by sex, with more females affected (Walker and Erlandson, 1986; Larsen, 1998; Schepartz *et al*., 2017). The same pattern characterizes many, but not all, contemporary populations (Mangi, 1954; Madléna *et al*., 2008). Shaffer *et al*. (2015) found that US Appalachian girls aged 6-11 years had significantly fewer caries compared to boys. However, during the adolescent years girls caught up with boys and then surpassed men in adulthood. This supports the view that female hormones influence caries experience.

The specific links of caries to pregnancy or parity are less clear. Rakchanok *et al*. (2010) demonstrated that the odds of caries experience in Thai pregnant women were almost three times more compared to non-pregnant women. However, Mangi (1954) failed to demonstrate a link between pregnancy and caries in an Indian population. There are few studies focusing on parity and caries and the findings are contradictory. Russell *et al*. (2010), using a large heterogeneous US sample, reported that women of high parity had more decayed and missing teeth due to caries compared to lower parity women who had more filled teeth due to caries. However, Ueno *et al.* (2013) failed to establish a link between parity and decayed/filled teeth in a Japanese population. Furthermore, studies from Africa (Walker *et al*., 1983; Scheutz *et al*., 2002) did not observe an association between parity and caries.

### *1.2.2 Parity and periodontitis*

Hormonal changes in pregnancy cause gingival inflammation (Morelli *et al*., 2018). While it is a logical inference that repeated pregnancies might worsen the health of the gingivae leading to periodontitis and eventual loss of teeth, reports on the association of parity and periodontitis are contradictory. Walker *et al*. (1983) noted that parity is linked to periodontitis in rural Black South Africa women. Similarly, Scheutz *et al*. (2002) and Taani *et al*. (2003) observed significant periodontal destruction in high parity women in Tanzania and Jordan respectively. On the contrary, Yas (2012) failed to demonstrate an association between parity and periodontitis in Baghdadi women.

### *1.2.3 Parity and tooth loss*

Considerable research has focused on causes of tooth loss and its impact on the quality of life, yet there are few studies on the relationship between parity and tooth loss and the available results are inconsistent. Russell *et al.* (2008), in a study of large sample of US White and Black non-Hispanic women, observed that parity was associated with tooth loss. Women from the lowest socio-economic status were likely to have more children and to lose more teeth compared to women from the middle and higher socio-economic statuses. Similarly, Christensen *et al.* (1998) found the same relationships between tooth loss, parity and socio-economic status for Danish twins. Halling and Bengtsson (1989) reported that high parity Swedish women lost their teeth earlier than nulliparous women and that parity was significantly associated with tooth loss. In Uganda, Wandera *et al*. (2009) established a significant positive association between parity and tooth loss in pregnant women, but Scheutz *et al*. (2002) found no link between parity and tooth loss in Tanzanian women. Socio-economic status may be a major modifiable determinant of the effect of parity on tooth loss.

### *1.2.4 Perceptions of women on parity and tooth loss*

General associations between higher parity and more teeth lost are documented among women of European ancestry (Rundgren and Osterberg, 1987; Halling and Bengtsson 1989; Christensen *et al.,* 1998). There are few quantitative data for African women or women in rural settings. No study has focused on how women view the role of parity in tooth loss. The views of women on this issue are essential to gain insights into their understanding and perception of parity and tooth loss (Appendix 1). This is particularly critical in contexts with significantly different parities and/or high parity. The perceptions of women are important as these may shape their behavior and attitudes towards oral health care.

## 1.3 Early childhood caries (ECC) and links to mother's oral health

Maternal oral health status impacts on children's oral health through several direct and indirect channels. Young children's dietary and oral health practices are determined by the mother or primary caregiver. One of the key indicators of childhood oral health is the caries experience. Early childhood caries (ECC) is the most common chronic oral condition of childhood (Mouradian, 2001). ECC refers to the presence of one or more decayed, missing or filled teeth due to caries in infants and preschool children aged 71 months or less (AAPD, 2011). The aetiology of ECC is multifactorial, and it is greatly influenced by maternal biological and socio-behavioural factors. Most often the child acquires the primary bacteria implicated in dental caries, *Streptococcus mutans*, from the mother (Berkowitz and Jordan, 1975; Caufield *et al*., 1993; Monse *et al*., 2010; Nourijelani *et al.*, 2014). *S. mutans* can be transmitted through kissing, sharing of utensils and pre-chewing of food (Aaltonen and Tenovuo, 1994). Mothers with high caries experience have high *Streptococcus mutans* counts and can easily transmit the bacteria to the child predisposing them to caries (van Houte and Green, 1974; Svanbero and Loesche, 1978).

### 1.4 Study aim and objectives

In order to evaluate the causal relationship between reproductive history and oral health, an appropriate study design that takes into consideration confounding variables relating to caries, tooth loss and reproductive history is important. Most available studies focused mainly on parity as a measure of reproductive history. The reproductive history consists of parity plus the total number of pregnancies, the age at first and last birth, the duration of birth intervals and the number of multiple births. Data on these other aspects of reproductive history are often unavailable or difficult to collect due to their sensitive nature involving miscarriages, abortions and stillbirths.

The association between parity and oral health, as measured by tooth loss, caries and periodontitis, remains unclear as most studies on these conditions are cross-sectional or not focused on parity. Many studies fail to define high parity or to include high parity women, or they fail to consider confounding factors. Therefore, it is difficult to verify a cause and effect relationship between parity and oral health.

*Aim*

To determine the associations between parity, age, nutritional status, socio-economic status, oral health practices (frequency of consumption of refined sugar and tooth brushing, use of fluoridated toothpaste and number of dental visits) and tooth loss, dental caries, periodontitis in Hausa mothers and dental caries in their children (ECC). that parity is related to tooth loss.

*Objectives*

1. To investigate the relationship between parity and dental caries in Hausa women.
2. To investigate the relationship between parity and periodontal disease in Hausa women.
3. To investigate the relationship between parity and tooth loss in Hausa women.

4. To investigate the interaction of socio-economic status, parity and oral health (caries, periodontal disease and tooth loss) in Hausa women.
5. To investigate the relationship between nutritional status and oral health (caries, periodontal disease and tooth loss) in Hausa women.
6. To investigate the effect of Hausa women's maternal oral health on their children's dental caries experience (ECC).
7. To investigate the perceptions of Hausa women on parity and tooth loss through focal discussion groups (FDGs).

The study hypotheses are as follows:

a. The number of full term pregnancies is not associated with caries experience in women.
b. The number of full term pregnancies is not associated with periodontal disease in women.
c. The number of full term pregnancies is not associated with tooth loss in women.
d. Socio-economic status is not associated with parity and oral health (caries, periodontal disease and tooth loss) in women.
e. Nutritional status is not associated with oral health (caries, periodontal disease and tooth loss) in women
f. Maternal oral health (caries) is not associated with caries experience in their children.
g. The women do not perceive that parity is related to tooth loss.

# Chapter 2

# Literature review

## 2.1 Introduction

The association between parity and maternal oral health status-- particularly tooth loss-- is a challenging research issue with a myriad of contributing factors to investigate. This chapter reviews the current literature on Maternal Depletion Syndrome (a possible explanation for the link between parity and tooth loss) and the relationship between parity and maternal oral health status as measured by caries, periodontal diseases and tooth loss. Contemporary knowledge of maternal physiological characteristics, behaviours relating to oral health status, as well as the relationship between maternal *Streptococcus mutans* level and early childhood caries are also considered.

## 2.2 Parity, maternal health and Maternal Depletion Syndrome (MDS)

### 2.2.1 *Parity*

Parity is a measure of female reproduction that considers the number of live births or stillbirths ≥20 weeks of gestation a woman has experienced (Bai *et al*., 2002). Solomons (1934) introduced the term *grand multiparity* (high parity) when he observed a positive correlation between high parity and risk of pregnancy complications. It refers to a woman having ≥5 live births or stillbirths of ≥20 weeks of gestation. Later the term *great grand multiparity* was suggested to denote women with ≥10 live births or stillbirths of ≥20 weeks of gestation (Abu-Heija and Chalabi, 1998).

Parity is different from Total Fertility Rate (TFR), which refers to the total number of children a woman will have if she lived from 15-50 years and experienced the age specific fertility rates of the period in question throughout those reproductive years (Spoorenberg, 2015). TFR is the most commonly used metric for average number of children per woman. According to the World Population Data Sheet (2014), TFRs range from a low of 1.1 in Taiwan to a high of 7.4 in Niger, with the highest TFRs observed in Africa. In Nigeria, the TFR is 5.7, with variation across the geopolitical zones. The highest rate, 7.3, is reported for the Northwest zone among the Hausa/Fulani population (NPC and ICF Macro, 2009).

### 2.2.2 *Maternal Depletion Syndrome (MDS)*

The process of reproduction in females can be stressful due to the energy demands associated with supporting pregnancy, lactation and childcare (Butte and King, 2005; Jasienska *et al.*, 2017). Pregnancy and lactation are associated with physiological, metabolic and nutritional changes. These adjustments can cause permanent changes in the mother's response to stress, particularly in high parity women (Jasienska *et al.*, 2017). Increased investments in reproduction, combined with short interbirth intervals, may deplete the mother of her nutritional reserves and can be detrimental to her health (Ellison, 2003). The cumulative effect of these stresses is referred to as "Maternal Depletion Syndrome" (MDS). MDS is associated with osteomalacia, which is believed to be a result of calcium depletion from bones and teeth with eventual loss of teeth (Winikoff and Castle, 1987). The belief that maternal nutritional depletion results in tooth loss has not been fully substantiated (Walker *et al.*, 1983; Cruikshank and Hays, 1991; Steinberg, 1999).

The physiology underlying tooth loss in MDS is not conclusively demonstrated. Aside from the suggested effects of osteomalacia, the idea that pregnancy itself triggers calcium to leach out of tooth enamel, and consequently increases the potential for caries, is not supported (Eastman, 1942 as cited in Lukacs and Largaesparda, 2006). Furthermore, the argument that maternal depletion results in tooth loss due to calcium depletion from bones has not been fully substantiated (Walker, Dison & Walker, 1983; Cruikshank & Hays, 1991; Steinberg, 1999), although a plausible mechanism for tooth loss is the effect of pregnancy on bone density. Black *et al.* (2000) and Ulrich *et al.* (2003) argued that pregnancy is characterized by high bone turnover with resorption and significant decreases in bone mineral density. The effect of this resorption on alveolar bone is reduced tooth retention during pregnancy and thereafter.

There are various theories regarding the mechanisms underlying MDS, ranging from biological factors affecting the woman to general sociological factors involving access and use of health services. The most general of these arguments asserts that the physical and caloric demands of repeated pregnancy, in combination with physical and caloric stresses of life at a basic subsistence level, lead to MDS (Jelliffe and Maddocks, 1964; Hobcraft *et al.*, 1983; DaVanzo *et al.*, 1984). The onset of pregnancy increases energy needs by 13%, protein needs by 54%, and vitamin and mineral demands up to 50% (Institute of Medicine (US), 2000; 2001). If a mother's reserves are depleted during pregnancy, the interbirth interval should allow for repletion prior to the conception of the next child. However, it is not clear if the ability to conceive necessarily means that a woman is fully recovered from prior pregnancy and lactation demands, and the concept of MDS builds on the posited cumulative effects of rapid successive pregnancies. Adebowale *et al*. (2011), in a study conducted among southwestern Nigerian women, demonstrated that birth intervals of at least 36 months result in the best nutritional outcomes for mothers. Similarly, in rural Butajira, Ethiopia, interbirth intervals of three to five years were considered safer for mothers compared to interbirth intervals of two years or less (Yohannis *et al*., 2003). In contrast, the WHO (2007) guidelines recommend a minimum of two years from a live birth to the next pregnancy. The different recommendations may reflect disparities in resources and reproductive burdens that are region specific.

The association between high parity and maternal morbidity (and also maternal mortality) is well established (Hobcraft *et al*., 1983; Stover and Ross, 2010). This relationship is observed worldwide, but especially in countries with higher fertility rates such as Nigeria, Mali and India (Sonneveldt *et al*., 2013). Proposed explanations for this relationship include biological risk factors as well as socio-economic factors pertaining to access to, and utilization of, health care services. In contrast, there is little documentation on the relationship between high parity and maternal oral health. Oral health is an integral part of general health that significantly affects an individual's quality of life. It is likely that the same factors that affect maternal general health may play a major role in the oral health conditions of high parity women. Therefore, there is a need to investigate the association between parity and oral health in general, and particularly in populations with higher fertility rates.

### 2.3 Dental caries

Dental caries is a chronic disease with a multifactorial, complex aetiology that involves the interplay of bacteria, refined carbohydrates and tooth surfaces over a period of time. Keyes (1968) illustrated the concept of caries using a Venn diagram that consist of three circles, representing bacteria in plaque, diet and susceptible tooth surfaces. Interaction between these circles over time results in caries formation. Dental caries is the most common oral health problem. Bioarcheologists have documented a significant increase in the prevalence of dental caries over human evolutionary history following the commencement and intensification of farming (Cohen and Armelagos, 1984; Lukacs, 1992).

### 2.3.1 *Assessment of dental caries*

Various techniques are employed to assess caries and these methods differ by discipline. In dentistry, a number of epidemiological indices are used to quantify caries for the determination of prevalence and population at risk. These indices include the DMFT (Decayed, Missing and Filled Teeth), DMFS (Decayed, Missing and Filled Surfaces), ICDAS (International Caries Detection Assessment System), PUFA (Pulpal involvement, Ulceration, Fistula and Abscess due to caries) and CAST systems (Caries Assessment Spectrum and Treatment) (Shyam *et al.*, 2017). The DMFT is the most widely used, well-established, simple, and universally accepted (Larmas, 2010). The DMFT score per individual is the sum of the decayed (D), missing (M) and filled (F) teeth (T) due to caries. When the index is applied to surfaces of teeth, it is referred to as the DMFS. Applications of the DMFT and DMFS for the primary dentition are the dmft and dmfs. A limitation of the DMFT index is that it does not provide information on the number of teeth at risk nor does it estimate treatment needs (Shyam *et al.*, 2017). However, the PUFA index measures the severity of caries and documents the advanced stages of untreated caries to inform policy makers on decisions regarding caries treatment and prevention (Oziegbe and Esan, 2013). In dental anthropology or skeletal biology, caries assessment is used to provide information on the life experience of a population or individual. The DMFT index is generally not used, but rather the presence of caries on a tooth or tooth surfaces is expressed as a frequency of affected teeth for the total number observed in a sample, or in terms of the number of caries lesions per tooth type or per individual dentition (Temple, 2016).

### 2.3.2 *Sex differences and dental caries*

Several studies identified a significant sex difference in the prevalence of dental caries in adults with higher levels in females in most populations. This bias is evident both in prehistoric and contemporary times, and has been attributed to a number of factors including earlier emergence of teeth in females with longer exposure to cariogenic oral environments, the influence of hormones and pregnancy, and the role of women in domestic food preparation and consumption (Lukacs, 2011a).

Dental anthropologists generally view behavioural variation as the primary explanation of sex differences in dental caries prevalence (Walker and Hewlett, 1990; Cohen and Bennett, 1993). A meta-analysis of prehistory caries rates revealed an almost ubiquitous pattern of sex differences (Lukacs and Thompson, 2007). Kelley *et al*. (1991) attributed the higher caries rates in ancient Chilean females to sexual division of labour with respect to food gathering, with females being the principal food preparers. Similarly, Larsen (1995) noted a higher caries rate in women of prehistoric Georgia and also attributed this to gender-based differences in food preparation and consumption. Furthermore, Lukacs (1992) and Lukacs and Pal (1993) documented a higher dental caries rates in female agriculturalists from Bronze Age Harappa and earlier "Mesolithic" female foragers of the Ganga Plain. The reason for the observed differences was ascribed to sexual division of labour and gender-based dietary behaviours, where women were characterized by high carbohydrate and low protein intake compared to males. Schepartz *et al.* (2017) documented this same pattern in Late Bronze Age Mycenaeans using stable isotope analysis in conjunction with caries and tooth loss. Access to animal protein was found to vary significantly by sex as well as position in the social hierarchy, with males having better oral health and higher protein consumption compared to females of the same social rank.

Large-scale studies on dental caries in contemporary populations show a clear pattern of females typically having more caries. Shaffer *et al*. (2015) compared caries experience across phases of dental development in two US Northern Appalachian populations. Sex differences were noted in the primary, mixed and adult permanent dentition stages. In the primary dentition phase (1-5 years), girls from Pennsylvania experienced more caries than boys, although the difference was not significant. The West Virginia boys had significantly more caries than girls in the mixed dentition stage. In the adult dentition (18-59 years), males and females had similar caries counts in both populations. However, females had significantly more filled teeth and males had significantly more decayed teeth (Shaffer *et al*., 2015). These results suggest that the youngest females benefited from caries protection, which was lost during adolescence, and that adult women accessed dental health significantly more than men. Madléna *et al*. (2008), in a Hungarian national survey, documented higher caries prevalences in females of all age groups compared to males. However, it should be noted that further analysis of these data revealed significantly greater caries experience for females in all cohorts *except* the youngest (<19 years) and oldest (75 years) (Lukacs, 2011a). In Asian populations, a study of aged-matched men and women in rural central India found a significantly greater caries experience in females than males across the age groups (Mangi, 1954). More recently, in an extensive meta-analysis of clinical and epidemiological studies on caries rates in South Asia, Lukacs (2011b) observed a pattern in which there is a shift to higher female caries rates from adolescence to the reproductive years. These results for contemporary populations collectively suggest that females have more caries and that male-female differences in caries generally increase over the lifespan.

### 2.3.3 *Sex hormones, saliva and dental caries*

The sex differences observed in caries rates may be due to the influence of sex hormones. Hormonal fluctuations and pregnancy have been argued to influence higher caries rates observed in females, although the exact mechanisms through which these two factors promote caries are not fully understood. Estrogen levels are known to increase significantly during menstruation and life-history events such as puberty and pregnancy (Niswender *et al.*, 1976; Worthman, 1995). Animal studies demonstrate that higher estrogen levels are associated with reduction in saliva flow rate and increased caries (Delman, 1955; Muhler and Shafer, 1955).

Saliva flow rate and saliva composition have multifunctional roles in the general oral health status as well as the caries susceptibility of an individual. Through its cleansing action, saliva reduces the availability of cariogenic bacteria (Lukacs and Largaespada, 2006). The bicarbonate buffering action helps to prevent demineralization of the enamel and to create an unfavourable environment for cariogenic bacteria (Dowd, 1999). The calcium and phosphate ions in saliva increase the hardness of the enamel following tooth emergence, thus making the tooth resistant to caries (Lukacs and Largaespada, 2006). Interestingly, females have significantly lower salivary flow rates compared to males (Percival *et al*., 1994; Dodds *et al*., 2005). It has been suggested that estrogen is responsible for this difference (Lukacs and Largaespada, 2006).

### 2.3.4 *Pregnancy and dental caries*

Pregnancy is associated with extreme hormonal fluctuations. Estrogen levels are higher during pregnancy than for any other period in the life cycle (Zachariasen, 1989; Amar and Chung, 1994; Lukacs and Largaespada, 2006). Pregnancy reduces the buffering capacity of saliva and promotes growth of cariogenic bacteria (Salvolini *et al*., 1998). Vomiting, neglected oral hygiene, cravings for refined carbohydrates and poor nutrition may also contribute to caries during pregnancy (Ferraro and Vieira, 2010).

There is surprisingly little research focusing specifically on the relationship between pregnancy and dental caries, given that many cultures believe that there is a link. This may be due to the difficulties of identifying pregnant women as research participants (Livingston *et al*., 1998). Several studies demonstrated a relationship between pregnancy and caries (Mangi, 1954; Rakchanok *et al*., 2010; Azofeifa *et al*., 2016). Rakchanok *et al*. (2010) noted a significantly higher caries rate in pregnant Thai women compared to non-pregnant women. The pregnant women were almost three times more likely to suffer dental caries. In contrast, a study in Indore, Central India failed to demonstrate an association between pregnancy and dental caries (Mangi, 1954). Similarly, a large national health and nutrition survey conducted in the US demonstrated no significant difference in caries rates between pregnant and non-pregnant women (Azofeifa *et al*., 2016). However, following stratification of the results by socio-demographic characteristics, the prevalence of untreated dental caries was significantly higher in pregnant than non-pregnant women (Azofeifa *et al*., 2016). This finding about differences in treated caries illustrates the need to examine caries experience within the broader context of the other issues women encounter during their reproductive years.

The studies by Rakchanok *et al*. (2010) and Azofeifa *et al*. (2016) failed to consider reproductive parameters such as parity of the participants. The comparisons were between pregnant and non-pregnant women and nulliparous status was not taken into account. Furthermore, only Azofeifa *et al*. (2016) considered the severity of dental caries. All these factors are likely confounders for caries that could affect the outcomes of these studies.

### 2.3.5 *Parity and dental caries*

The biological effects of repeated pregnancies on the oral environment may relate to elevated dental caries rates in females. Based on available evidence, the relationship between parity and dental caries is not consistent across populations. Russell *et al*. (2010) observed a positive correlation between parity and untreated dental caries in a large heterogeneous sample of US women. Higher parity women were more likely to have missing teeth, while lower parity women were more likely to have filled teeth due to caries. The majority of the participants were of low parity. However, it is not clear from the study if higher parity women had dental insurance or visited the dentist. Although it is stated that parity was inversely related to socio-economic status, there were women of high parity (5 or more children) in both the middle and high socio-economic statuses (Russell *et al*., 2010). Therefore, it is difficult to generalize from this study. In a different study, Ueno *et al*. (2013) did not observe a significant relationship between parity and number of decayed/filled teeth among Japanese women. However, the researchers did not relate parity and dental caries to the socio-economic status of the participants.

A study conducted on rural Black South African women failed to detect a significant difference in the caries rates of high and low parity women (Walker *et al*., 1983). The women in the study had lower caries rates than White women of low parity who had high calcium diets, better access to dental care, and greater treatment utilization. Another study of Tanzanian women did not observe any association between parity and dental caries (Scheutz *et al*., 2002). This suggests that dietary composition, and particularly traditional African diets, were not major contributors to Black African women's caries experience (Walker *et al*., 1983; Scheutz *et al*., 2002). The prevalence of caries in Africa is quite low and mostly untreated, although there are regional variations (Thorpe, 2006). The possible implications of this are low priority placed on care of the teeth, inadequate oral health services and increased tooth loss. Further studies in Africa are needed to explore the possible relationship between parity and caries.

## 2.4 Periodontal disease

Periodontal disease is a common inflammatory condition of tooth supporting structures that results in destruction of attachment tissues and eventual tooth loss in severe cases. It is a multifactorial condition involving a complex relationship between the host and bacteria. Periodontitis is usually preceded by inflammation of the gingiva. Thus, repeated episodes of gingivitis during pregnancies might result in chronic inflammation of the periodontium (Offenbacher *et al*., 2006). Although gingivitis reflects the level of oral hygiene, it is a poor predictor of subsequent periodontal disease because tissue damage can be reversed (Albandar, 2002a).

Albandar (2002b), in a large survey of the US population, reported that Blacks were twice as likely as Whites to be affected by periodontitis, and that males were more affected than females. In other studies that controlled for age and type of periodontitis, young females were found to be at greater risk for aggressive periodontal disease (Albandar and Tinoco, 2002). Important risk factors for periodontitis include age, poor plaque control, smoking, low socio-economic status, poor education, diabetes, HIV infection, low dental care utilization, sex hormones, parity and psychosocial stress (Craig *et al*., 2001; Hyman and Reid, 2003; Borrell and Crawford, 2008; Apoorva and Suchetha, 2010).

### 2.4.1 *Assessment of periodontal disease*

Over the years, different techniques for assessing periodontal disease were employed, but none of these methods has been able to measure periodontal disease accurately. This has resulted in underestimation and made comparison of results difficult. The Russell Periodontal Index (PI) was the first index developed and was widely used between 1950 and 1970 (Dhingra and Vandana, 2011). The index scores all the teeth in the mouth on an ordinal scale (Dye and Thornton-Evans, 2007). A major disadvantage of this index was that it considered gingivitis as equivalent to early periodontitis. In addition, it did not consider features specific to periodontitis such as pocket depth, clinical attachment level and radiographic loss (Dhingra and Vandana, 2011). Consequently, the index was considered non-valid. The Community

Periodontal Index of Treatment Needs (CPITN) was developed in the 1980s (Jacob, 2011). It assesses the presence or absence of bleeding on slight probing, supra- or sub-gingival calculus, and pocket depth using a 0.5 mm ball tip WHO probe. Ten index teeth are examined, but only the worst finding from the teeth is recorded per sextant of teeth (Dhingra and Vandana, 2011). However, the hierarchical principle underlying the CPITN scores is not universally valid, and the partial recording approach may grossly underestimate the prevalence of deep pockets (Baelum and Papapanou, 1996). The Community Periodontal Index, a modification of the CPITN, was developed in 1997. The CPI index includes the "loss of attachment" and excludes the "treatment needs" categories (Dhingra and Vandana, 2011. It is measured with a 0.5 mm ball tip periodontal probe with graduated markers. The index considers 10 teeth and determines the presence of gingival bleeding, supra- or sub-gingival calculus, and periodontal pockets with probing depths of 3.5-6.0 mm including attachment loss (Dhingra and Vandana, 2011). A drawback of the index is the validity of the hierarchical scoring principle and limited number of teeth examined, although, it is considered to be representative of the entire mouth (Benigeri *et al*., 2000; Dhingra and Vandana, 2011). The CPI is useful in periodontal research on adults and adolescents and is included as part of WHO Oral Health Surveys (Jacob, 2011).

The various indices for the assessment of periodontal diseases measure past disease activity and little of the present disease state. A combination of clinical attachment loss and radiographic assessment may give a better reflection of the disease condition (Dhingra and Vandana, 2011).

### 2.4.2 *Sex hormones and periodontal diseases*

The female sex hormones estrogen and progesterone influence the development of periodontal disease. Changes in the periodontium are linked to hormonal variations (Plancak *et al*., 1998; Mealey and Moritz, 2003; Jafri *et al*., 2015). These hormones have pronounced effects on the oral cavity and their receptors have been identified in the gingiva, periodontal ligament fibroblasts, and osteoclasts (Lopatin *et al*., 1980; Pack and Thomson, 1980; Vittek *et al*., 1982; Eriksen *et al*., 1988; Komm *et al*., 1988; Sooriyamoorthy and Grower, 1989). Estrogen and progesterone affect the periodontium through inhibitory effects on the immune system, leading to marked gingivitis in the presence of little or no plaque (Hofmann *et al*., 1986; Ito *et al*., 1995;

Reinhardt *et al*., 1999; Fessler, 2002). Puberty, menstruation, pregnancy and menopause have been demonstrated to affect periodontal health in women (Güncü *et al*., 2005; Nirola *et al*., 2018). Fluctuations in sex hormones during the menstrual cycle have been linked to periodontal changes (Alvergne and Tabor, 2018). Shourie *et al*. (2012) observed that women with healthy gingiva experienced little or no change to the gingiva throughout the menstrual cycle; however, those with evidence of gingivitis had exaggerated gingival inflammation during ovulation and pre-menstruation compared to the menstruation period. This shows that female reproductive physiology, aside from pregnancy-related changes, can affect the periodontium.

Estrogen and progesterone have been found to affect the oral cavity (Sooriyamoorthy and Gower, 1989; Juul, 2001; Jafri *et al*., 2015; Silva de Araujo Figueiredo *et al*., 2017). These hormones increase oral vascular permeability and inhibit the immunocompetence of the host (Güncü *et al.*, 2005; Jafri *et al*., 2015). The resultant effect is hyperactivity of the gingivae leading to gingivitis and subsequently periodontitis (Kornman and Löesche, 1980).

2.4.3 *Pregnancy, gingivitis and periodontal disease*

The relationship between pregnancy and increased gingivitis is conclusively demonstrated. Hugoson (1971) observed an increase in severity of gingivitis with increased levels of sex hormones during pregnancy. This was followed by a reduction in severity after childbirth. Similarly, Kornman and Loesche (1980) demonstrated a positive correlation between female sex hormones, gingivitis and microbial changes. Pregnancy is associated with reduced immune response; thus gingivitis may manifest even in the presence of little plaque (Fessler, 2002). Pregnant Thai women were 2.2 times more likely to have gingivitis than non-pregnant women after controlling for age (Rakchanok *et al*., 2010). In a systematic review of 33 prospective cohort and cross-sectional studies on the association between pregnancy and gingival inflammation, Figuero *et al*. (2013) reported support for an association with a significant increase in gingivitis throughout pregnancy. Pregnant women experienced more gingivitis compared with postpartum and non-pregnant women.

While the continuous increases in estrogen and progesterone during pregnancy are associated with increased gingivitis and periodontitis (Laine, 2002; Russell and

Mayberry, 2008; Silva de Araujo Figueiredo *et al*., 2017), the link between pregnancy and periodontitis is more difficult to verify. The progression from gingivitis to periodontitis is not inevitable, and when it does occur the process involves varying periods of time, differing levels of severity and timing of onset, and even tissue recovery in some cases. This may explain why some studies, such as Tilakaratne *et al*. (2000) and Gursoy *et al*. (2008), failed to demonstrate a relationship among pregnancy, gingivitis and periodontitis. Most recently, Morelli *et al*.'s (2018) review of longitudinal studies on parity, pregnancy and periodontal disease observed that while elevated periodontal disease is observed during pregnancy, it is reversible. However, it is not clear if pregnancy aggravates pre-existing periodontal destruction because most studies do not follow up for sufficient periods postpartum.

2.4.4 *Parity and periodontal disease*

There is substantial evidence for periodontal disease among women of childbearing age. However, there are very few studies focusing on parity and periodontal disease and the available evidence is not conclusive as to whether the two are associated. Two studies of African women illustrate a positive association between parity and periodontitis. Scheutz *et al*. (2002), in a study of Tanzanian women from Dar es Salaam, observed that women with more than three children had significantly more periodontal attachment loss. Similarly, a significant association was observed between parity and periodontal status of young pregnant Ugandan women in rural and urban settings (Wandera *et al*., 2009).

High parity Jordanian women had increased periodontal disease compared to their monoparous counterparts (Taani *et al*., 2003). The study was limited to women who presented at the government hospital in an urban setting and the duration of follow-up postpartum was not indicated. Similarly, a study of young Sudanese women demonstrated a positive relationship between high parity and periodontal status (Elrayah and Osman, 2016). However, the study failed to relate the oral hygiene habits and status of the women to their parity levels and periodontal status. It is likely that women with more children are more stressed and may not be able to carry out adequate oral hygiene measures, which in turn worsens their oral health status.

Contrary to the studies that found an association between parity and periodontitis severity, Yas (2012) and Onigbinde *et al*. (2014) found that high parity had no pronounced influence on the periodontal status of pregnant women from Baghdad and Nigeria respectively. Yas (2012) observed that both multigravidae and primigravidae women had similar probing pocket depths.

Part of the problem underlying the mixed results for parity and periodontitis relates to the different ways periodontal disease is measured, the period of time that lapses between the onset of the disease and when it is evaluated, and the often poor documentation of the oral hygiene levels of the study participants. Most studies on pregnancy, parity and periodontitis were conducted during the pregnancy and immediate postpartum periods and were of short duration. Since pregnancy induced periodontitis is considered reversible, studies with longer post delivery follow-up are required to effectively explore the effects of pregnancy and parity and any cumulative costs of short birth intervals on periodontal health.

## 2.5 Tooth loss

The contribution of high parity to tooth loss is the essential question that is explored in this study. Teeth contribute to an individual's wellness and appearance, and the absence of teeth is associated with reduced quality of life (Eli *et al*., 2001; Saintrain and de Souza, 2012). Tooth loss can be a useful indicator of an individual's oral health because it is simple to measure and directly related to oral function and general health condition (Russell *et al*., 2013). Yet tooth loss is the result of multifactorial processes involving infection and deterioration of the tooth structure or supportive tissues in an oral environment shaped by dietary composition and its abrasive qualities, hormonal changes, oral hygiene and dental treatment. In addition, teeth can be lost to trauma and cosmetic cultural practices; this primarily affects the more vulnerable and visible anterior teeth. It is often not possible to determine the precise aetiology of tooth loss when the alveolus has been substantially remodeled and the tooth socket is no longer observable.

Globally, periodontitis is a major cause of tooth loss. A search of the literature on the causes of tooth loss in various populations identified periodontal disease as the second most common cause of tooth loss, following dental caries (Cahen *et al*., 1985; McCaul *et al*., 2001; Quteish Taani, 2003; Richards *et al*., 2005; Esan *et al*., 2010).

2.5.1 *Sex differences in tooth loss*

It has been posited that there are disparities in the rates of tooth loss for males and females. This argument is based on differing prevalences of the oral diseases that are major causes of tooth loss, and observations that diet as well as certain cultural practices linked to tooth loss vary by sex (Russell *et al*., 2013).

In the dental anthropology literature, tooth loss is classified as either antemortem tooth loss (AMTL), referring to teeth lost during life as indicated by resorption of the alveolar bone; or tooth ablation/evulsion, which is the deliberate excision of anterior teeth during life (Pietrusewsky and Douglas, 1993; Lukacs, 2012). AMTL is a result of disease processes or trauma, while tooth removal stems from cultural practices that include social identity construction and aesthetic choices, life transition rituals, and ethnomedical treatments (i.e., removal of deciduous canines to control fever) (Russell *et al*., 2013; Garve *et al*., 2016).

Sex differences in tooth loss have been documented in prehistoric skeletal biology studies. Many bioarcheological analyses describe more tooth loss in women (Nelson *et al.*, 1999; Cucina and Tiesler, 2003; Oyamada *et al.*, 2007; Watson *et al.*, 2010). Women's oral health declined more rapidly compared to men's following the commencement of farming and subsequent increases in fertility rates over the past several thousand years (Lukacs, 2011a). AMTL accounts for a majority of teeth lost in prehistory, while tooth ablation accounts for a smaller proportion (Milner and Larsen, 1991). In many instances significant sex differences were noted in AMTL relating to caries and periodontitis, with more women affected than men (Russell *et al*., 2013). In contrast, sex disparities in dental ablation are significantly influenced by sociocultural practices that reinforce gender roles (Russell *et al*., 2013). Within Africa, widespread dental ablation was reported for the Maghreb region of northern Morocco, Algeria and Tunisia with both sexes equally affected during the Iberomaurusian and Transitional Epipalaeolithic periods. In the later Caspian period, females had more dental ablation than males. This suggests a possible change in the social meaning of tooth ablation (Humphrey and Bocaege, 2008), or even new patterns of mate exchange. Tooth ablation is documented in parts of eastern, central and southern Africa from prehistory through to the modern day (Friedling and Morris, 2005; Pinchi *et al*., 2015). Coupled with dental modifications such as filing and hatching, tooth ablation was, and continues to be, an effective signal of social identify.

Comparable to what occurred in prehistory, tooth loss in contemporary humans is also patterned by sex differences in oral conditions and social behaviours. In most parts of the world, higher rates of tooth loss are reported for women (Nalçacı *et al*., 2007; Cheng *et al*., 2009; Lukacs, 2011a; Lukacs, 2011b), and these are related to differences in caries and periodontal disease prevalences, as discussed above. Clinical studies document more tooth loss in women as well (al Shammery *et al.*, 1998; López and Baelum, 2006; Corraini *et al.*, 2009; Shigli *et al.*, 2009). Novel factors that distinguish differences in tooth loss by sex in contemporary populations include adoption of Western cariogenic diets and major disparities in socio-economic status (associated with access to, and utilization of, dental care and preventive dental care) (Russell *et al*., 2013).

Identified contributors to greater tooth loss in women include socio-economic status and disposable income available for dental care, culture–based divisions of labour, gender-based dietary differences with higher carbohydrate to protein ratios, snacking during food preparation, consumption of refined sugars and smoking (Monteiro da Silva *et al.*, 1998; Cruz *et al.*, 2005; Russell *et al.*, 2008). Socio-economic status has been argued to be a key contributor to women's oral health status and related tooth loss, with individuals of low socio-economic status found to have the poorest oral health conditions (Cunha-Cruz *et al*., 2007; Holst, 2008; Celeste *et al*., 2011). However, Cabrera *et al.* (2005), in a 24-year follow-up study of Swedish women, suggested that the association between tooth loss and cardiovascular disease could not be explained by factors such as occupational status, income and educational level. They argued that residual confounding could account for the association as some risk factors (physical activity, diet, family history of disease) were not captured in their study (Cabrera *et al.*, 2005). More recently, Wennström *et al*. (2013), in a cohort comparison of Swedish women, demonstrated an inverse association between number of teeth and socio-economic status.

2.5.2 *Parity, pregnancy and tooth loss*

The relationship between pregnancy and tooth loss, while widely believed to exist, is very difficult to study- except through the perspective of parity. The reason for this is simply that tooth loss is typically the culmination of degenerative biological processes rather than an event. Thus, it is very unlikely that loss of a tooth can be tied to a particular pregnancy, even though the demands of the pregnancy may have triggered the degenerative processes. Focusing on parity rather than pregnancy provides the opportunity to view tooth loss as a process.

A plausible mechanism for greater tooth loss in women is the effect of pregnancy on bone density. Black *et al.* (2000) and Ulrich *et al.* (2003) argued that pregnancy is characterized by high bone turnover with resorption and significant decrease in bone mineral density. The effect of this is poor tooth retention during pregnancy and thereafter. Thus, the cumulative effects of pregnancies may result in fewer teeth. Meisel *et al.* (2008) and Russell *et al.* (2008), in studies conducted among German and American women respectively, argued that tooth loss increases with parity.

A comprehensive literature search on the association between pregnancy, parity and tooth loss in women was conducted using the Pubmed and SCOPUS search engines. Most studies on parity and tooth loss are cross-sectional and only a few are well representative of higher parity women (Table 2.1). The exceptions are studies from South Africa and Tanzania, in which half of the participants were high parity (Walker *et al*., 1983; Scheutz *et al*., 2002). Wandera *et al*., (2009) do not provide information on the parity range of Ugandan women in their study. Investigations conducted in very different contexts demonstrated associations between parity and tooth loss. Rundgren and Osterberg (1987), in a study of three urban Swedish cohorts, demonstrated that the number of teeth present negatively correlated with the number of children. High parity women lost their teeth earlier compared to their nulliparous counterparts. Similarly, another large study of the Swedish population confirmed that high parity was associated with increased tooth loss (Halling and Bengtsson, 1989). This was more evident in women of low socio-economic status, and increased tooth loss occurred in women with more than five children. Christensen *et al*. (1998)

conducted a unique study of Danish twins. Thirty-four identical twin sets of the same socio-economic status but different parity levels were compared. For 28 of the pairs, the twin with more children had significantly fewer teeth present. Twins of low socio-economic status lost a tooth per child compared to a tooth per two children for high socio-economic status women. Furthermore, more high parity women were edentulous compared to those without children in both high and low socio-economic classes. This difference was more obvious in the low socio-economic group. A study of German women established that approximately one tooth was lost per child in all the age cohorts, and that women with children had less teeth compared to their nulliparous peers (Mesiel *et al.,* 2008). Russell *et al*. (2008), in study of urban white and black non-Hispanic American women, observed that high parity was associated with increased missing teeth despite controlling for confounders. Among urban Japanese women, Ueno *et al*. (2013) observed a significant relationship between parity and tooth loss, with women of parity greater than three losing nearly three more teeth than nulliparous or monoparous women. Similarly, Han *et al*. (2016), in a study of postmenopausal Korean women, observed a positive correlation between parity and tooth loss. A study of pregnant Ugandan women demonstrated a positive association between parity and tooth loss in young low-income women (Wandera *et al*., 2009).

The generalisabilty of research results on parity and tooth loss is often difficult to assess because of design limitations. Two studies in Table 2.1 reported no association between parity and tooth loss. This may be due to aspects of study design. Scheutz *et al*. (2002) excluded women 50 years and above, and Walker *et al*. (1983) excluded women over 55 years. While it is not possible to determine if tooth loss in older age cohorts is directly caused by the stresses associated with reproduction, any cumulative effects of parity (especially high parity) on tooth loss are expected to be more apparent in older age cohorts. Thus, these investigations may have failed to capture the full picture for their sampled population.

The majority of parity/tooth loss studies, with the exception of the German study by Meisel *et al*. (2008), failed to consider components of oral hygiene status that provide information on the basic oral environment. Most studies considered socio-economic class and marital status (Rundgren and Osterberg 1987; Halling and Bengtsson, 1989; Christensen *et al*., 1998; Mesiel *et al.*, 2008; Russell *et al*., 2008). The majority noted that women of low socio-economic status had fewer teeth compared to their counterparts of high socio-economic status. A large number of the studies did not define high parity or failed to consider the number of pregnancies (as opposed to number of living children), interbirth intervals or the duration of breastfeeding. These variables have a major effect on the maternal nutritional reserves and consequently may be linked to tooth loss. The effect of parity on tooth loss has therefore not been adequately researched by taking into account other reproductive parameters such as number of pregnancies, interbirth intervals and duration of breastfeeding as well as aspects of oral hygiene.

Although many studies established that parity is inversely related to the number of teeth present, a causal effect relationship is important to verify the evidence. Recently, Gabel *et al*. (2018), in cross-sectional study that involved 27 European countries and Israel, established causal links between parity and tooth loss. Using a two stage least squares regression, a strong causal link was noted for an additional child after the first two children. This study design may not be appropriate as it relied on self-reported oral health status, which is likely to be different from objective clinical assessment by a dentist. There is the tendency for individuals to over or under report previous or current dental status. In addition, the study included a wide range of countries and cultural settings and this could also affect participants' subjective interpretation of their own as well as their child's oral health status.

2.5.3 *Behavioural factors, parity and tooth loss*

The association among parity, tooth loss and socio-economic status is complex, but positive associations have been identified. Socio-economic status was used as a general proxy for a range of disparities that involve variation in oral health habits linked with tooth loss. For example, Russell *et al.* (2008), in a study of American women, confirmed a relationship between parity and tooth loss. However, the relationship was not moderated by behavioural factors such as dental care, psychosocial factors and dental health-damaging behaviours. Therefore, it is possible that the increased tooth loss observed in women is moderated mostly by biological factors and modified by socio-behavioural factors (Mesiel *et al.*, 2008).

Difficulty in accessing dental care and utilization of available care are documented as contributing to more tooth loss in high parity and pregnant women. Only two of the parity/tooth loss studies (Meisel *et al*., 2008; Russell *et al.*, 2008) considered visits to dentists. Pregnancy and maternity are known to alter dental care utilization patterns (Gaffield *et al*., 2001; Timothe *et al*., 2002; Wandera *et al*., 2009). Most pregnant women undergo dental care only during the second trimester (Livingston *et al*., 1998). Dental care during the first and third trimesters is often deferred or modified by dentists (Livingston *et al*., 1998; Pistorius *et al*., 2003). Silberman *et al.* (1980) and Gaffield *et al.* (2001) found high levels of dental disease and treatment needs among pregnant women in the US. However, the number of pregnant women who attended the dental clinic was low (Gaffield *et al.*, 2001). Pregnant and high parity women may modify treatment plans to accommodate income concerns and their ability to comply with scheduled appointments. Given limited time and resources, they may opt to engage in preventive measures through oral self-care (Redford, 1993; Smith and Jasinevicius, 1996). D'Elio *et al*. (1997) observed that high parity might be associated with decreased dental insurance coverage.

Pregnancy, parity and access to dental care are associated with psychosocial factors (social support and financial stress) contributing to tooth loss (Moses-Kolko and Roth, 2004; Glazebrook *et al.*, 2004). There are additional psychological consequences such as anxiety and postpartum depression (D'Elio *et al*., 1997; Moses-Kolko and Roth, 2004; Glazebrook *et al.*, 2004). These consequences can affect the oral health directly via alterations of the immune system (LeResche and Dworkin 2002; Persson *et al.*, 2003; Saletu *et al.*, 2005), or indirectly through behavior such as smoking and non-compliance with dental treatment (Monteiro da Silva *et al.*, 1998; Gilbert *et al.*, 2000; Broder *et al.*, 2002; McGrath and Bedi, 2002). High parity has been linked to relapse in smoking after childbirth (Kahn *et al.*, 2002). This is demonstrated to have deleterious effect on the oral health with tooth loss as one of the harmful outcomes (Mai *et al*., 2013). The cumulative effects of an altered immune system, the anxiety and depression caused by pregnancy and parity, and the coping responses such as smoking, can be harmful to the oral health (Russell *et al.*, 2008). Thus, further studies that consider these factors, in addition to parity, are necessary to fully understand the role of parity in tooth loss.

**Table 2.1 Studies on parity and tooth loss**

| Population | Age range (years) | Parity Type | Parity range | Result* | Authors |
|---|---|---|---|---|---|
| Rural Black South African | 35-54 | Low parity vs. high parity | 1 - ≥5 | - | Walker *et al*., 1983 |
| Urban Swedes | 70 | Multiparous vs. nulliparous | 0 - ≥5 | + | Rundgren & Osterberg, 1987 |
| Urban Swedes | 38-60 | Multiparous vs. nulliparous | 0 - ≥5 | + | Halling & Bengtsson, 1989 |
| Urban Danes | ≥73 | Danish twins | 0 - ≥5 | + | Christensen *et al*., 1998 |
| Tanzanians | 25-49 | Parous vs. pregnant | 0 - 12 | - | Scheutz *et al*., 2002 |
| Urban Germans | 20-80 | Multiparous vs. nulliparous | 0 - ≥4 | + | Meisel *et al*., 2008 |
| Urban US White & Black non-Hispanics | 18-64 | Multiparous vs. nulliparous | 0 - ≥7 | + | Russell *et al*., 2008 |
| Rural & Urban Ugandans | ≤20-45 | Multiparous vs. nulliparous | 0 - ≥1[#] | + | Wandera *et al*., 2009 |
| Urban Japanese | 55-75 | Nulliparous vs. multiparous | 0 - ≥4 | + | Ueno *et al*., 2013 |
| Koreans | 46-75 | Monoparous vs. multiparous | 0 - ≥5 | + | Han *et al*., 2016 |

*'-' parity not related to tooth loss;'+' parity related to tooth loss ; [#] parity range is not given

### 2.6 Early childhood caries

The oral health of mothers impacts the health of their children in direct and indirect ways. The relationship between maternal caries and dental decay in young children is a component of the parity/oral health picture that warrants further investigation.

Higher parity women tend to have more caries experience. A positive correlation exists between caries experience and *Streptococcus mutans* level (Lenander-Lumikari and Loimaranta, 2000; Pannu *et al*., 2013). Mothers with high caries activity have high counts of *Streptococcus mutans* and can infect their child in the early years, thus increasing the susceptibility of the child to caries.

Dental caries is a serious public health issue for young children in both developed and developing countries (Livny *et al*., 2007). Early childhood caries (ECC) is the presence of at least one or more smooth surface caries or filled/missing teeth due to caries in children under 72 months of age (AAPD, 2011). In the past, ECC was referred to as “milk bottle mouth”, “nursing caries”, “nursing bottle caries”, “baby bottle decay”, “comforter caries” and “baby bottle syndrome” (Fass, 1962; Dilley *et al*., 1980; Ripa, 1988). These terms point to the infant care practices, involving bottle feeding and pacification, which were presumed to be the cause of the decay. It is now understood that the aetiology of ECC is multifactorial, as mothers not fitting the behavioural profile have children with ECC.

It has been argued that ECC is related to feeding practices in children. Studies established a link between inappropriate use of bottle-feeding and caries (Holt *et al*., 1988; Schwartz *et al*., 1993; Ayhan *et al*., 1996). This includes frequent, extended day and night use of bottles filled with sweetened drinks including fruit juices. In addition, breastfeeding pattern and duration has been linked to caries experience in children. There is no agreement on the results of available studies regarding breastfeeding and caries. South Asian children were found to be likely to suffer from caries when nocturnal breastfeeding was continued after the age of 12 months (van Palenstein Helderman *et al*., 2006). Furthermore, Folayan *et al*. (2010) documented that prolonged age of breastfeeding was significantly associated with caries experience in Nigerian children. Children who were breastfed for longer than 18 months had more caries. However, Iida *et al*. (2007) reported that breastfeeding and its duration were not associated with the likelihood of caries experience in US children. Likewise, Masumo *et al*. (2012), in a large survey conducted in Manyara, Tanzania and Kampala, Uganda, observed an inverse relationship between breastfeeding and caries. Children who were not breastfed had the highest level of caries experience. It is posited that breast milk itself is not cariogenic but it promotes caries in the presence of refined sugar (Ribeiro and Ribeiro, 2004). In order to determine an association between breastfeeding and caries it is important to consider the level of refined sugar consumption.

### 2.6.1 *Prevalence of ECC*

Globally, the prevalence of ECC is increasing, with variation in the level of experience within and among populations. Burt and Eklund (1999) noted a prevalence range of 1-12% in developed countries. Elsewhere the ECC picture is quite different.

In Asia, Tsai *et al*. (2006) observed a total prevalence of 56% in Taiwanese preschool children and Carino *et al*. (2003) documented 85% ECC in a sample of 3-year-old Filipinos. In Africa, studies from Kenya, Uganda and South Africa (Masiga and Holt, 1993; Khan and Cleaton-Jones, 1998; Kiwanuka *et al*., 2004) reported ECC in 38%, 45% and 47% of 3-year-olds respectively. In contrast, Folayan *et al*. (2015) observed a low total prevalence of 6.6% in Nigerian preschool children. Variation in diagnostic criteria for caries and study design may be the reasons for the observed differences. While most studies from Africa (Masiga and Holt, 1993; Khan and Cleaton-Jones, 1998; Kiwanuka *et al*., 2004) were school based, the study by Folayan *et al*. (2015) was a household survey, which is highly representative of the sample population. Thus, the findings can be generalized to the population.

ECC is a highly preventable disease, however the majority of the cases are untreated (Kassebaum *et al*., 2015). Untreated caries affects both the oral and general health of the child, and impacts negatively on their quality of life. Caries is often associated with pain and infections (abscess and cellulitis) that disturb sleep and mastication. The broader consequences are absenteeism at school, poor learning, hospital admission, the need for general anaesthesia during treatment, and malnutrition (Acs *et al*., 1992; Ayhan *et al*., 1996; Ladrillo *et al*., 2006; Blumenshine *et al*., 2008). Malnutrition in young children can cause enamel defects such as hypoplasia, which in turn predisposes the teeth to caries. In addition, children with ECC have a high risk of caries in the permanent teeth (Li and Wang, 2002).

ECC involves a dynamic interaction between acid producing bacteria, sugar and susceptible tooth surfaces. It is a chronic infectious disease that has *Streptococcus mutans* as one of the primary causative factors (Davey and Rogers, 1984; Ramos-Gomez *et al*., 2002). There is evidence strongly suggesting transmission of the bacterium from mother to child (Berkowitz and Jordan, 1975; Berkowitz and Jones, 1985; Davey and Rogers, 1984; Caufield *et al*., 1993). Thus, children of mothers with high salivary *Streptococcus mutans* counts and extensive tooth decay are considered to be at risk of developing dental caries (Boggess and Edelstein, 2006).

2.6.2 *Transmission of ECC*

2.6.2.1 *Maternal child transmission (vertical transmission)*

The early childhood years, especially 6 to 36 months of age, are considered crucial for acquisition of *Streptococcus mutans* (Davey and Rogers, 1984; Aaltonen and Tenovuo, 1994). High maternal salivary levels of *Streptococcus mutans* and frequent inoculation favour transmission from mother to child (Jordan *et al*., 1972; van Houte and Green, 1974; Svanbero and Loesche, 1978). The bacterium is transmitted via maternal saliva to the child through maternal habits such as sharing of utensils, licking of pacifiers and kissing (Aaltonen and Tenovuo, 1994). The establishment of caries in the child's mouth is dependent on additional factors such as frequency of consumption of refined carbohydrate, premastication of food, oral hygiene and use of fluoride toothpastes.

It has been suggested that an association exists between maternal salivary *Streptococcus mutans* and infant salivary *Streptococcus mutans* levels (Berkowitz *et al*., 1981; van Houte *et al*., 1981; Brown *et al*., 1985). In the US, Caufield *et al*. (1988) confirmed a positive correlation between the *Streptococcus mutans* levels of mother-child pairs. Higher levels of *Streptococcus mutans* were characteristic of mother-child pairs for children with severe ECC in an Arabian population. Mothers of children with severe ECC had higher levels of *Streptococcus mutans* compared to mothers of caries-free children (al Shukairy *et al*., 2006). Aaltonen and Tenovuo (1994) found no association between maternal salivary S. *mutans* levels and that of their children in a Finnish cohort study of 5-7 year olds. The age of the children may affect these results in that mother-child transmission patterns are age-dependent.

Crucial to identifying the probable source of *Streptococcus mutans* in the child is determining if the strain of S. *mutans* is shared between mother and child (Dasanayake *et al*., 1995; Li and Caufield 1995). Damle *et al*. (2016) identified similar strains in 77% of mother-child pairs in an Indian population. Similarly, Klein *et al*. (2004) demonstrated 81% genotypic similar strains among Brazilians pairs. It has been argued that the strain of salivary *Streptococcus mutans* harbored by the mother is critical in the transmission of the bacteria. Children of mothers below the threshold of infectivity ($10^6$ colony-forming units (cfu) per ml) have been demonstrated to be infected. A probable explanation is that the mothers of these children may harbour highly communicable strains, salivary factors in the child may favour initial adherence of the bacteria (Kohler *et al*., 1983). There is dearth of information from Africa, and in particular Nigeria, on the relationships between maternal and child *Streptococcus mutans* level, the genotype of S. *mutans* strains and caries.

*2.6.2 Horizontal transmission of ECC*

Vertical transmission (mother to child) is not the only route through which children can acquire *Streptococcus mutans*. Horizontal transmission can also occur between the child and family members (father or siblings) or peers at school (van Loveren *et al*., 2000; Ersin *et al*., 2004; Liu *et al*., 2007; Doméjean *et al*., 2010). Ersin *et al*. (2004), demonstrated a high degree of homology between *Streptococcus mutans* and family members in 2 to 3 year old Turkish children, as mother and father shared the same strain with their children. Similarly, Chinese children aged 3 to 4 years who attended day and night nursery school showed evidence of horizontal transmission. Thirteen of the children had two identical strains of *Streptococcus mutans* (Liu *et al*., 2007). In addition, extra-familial acquisition of *Streptococcus mutans* was observed in 5 to 6 year old children in the US (Doméjean *et al*., 2010). It is obvious that the mother is not the only source of infection for the child. The occurrence of mother-child matching strains decreases as the age of the children increases (Li and Caufield, 1995).

In addition to the biological factors discussed above, various risk factors such as socio-economic status, maternal level of education, oral health knowledge, parental attitudes and diet are linked to ECC. Some studies (Feldens *et al*., 2010; Zhou *et al*., 2010; Peltzer and Mongkolchati, 2015) demonstrated a significant association between mother's level of education and ECC. Feldens *et al*. (2010), in a cohort study of Brazilian children, noted that children whose mother's education level was less than 9 years were 1.5 times more likely to have ECC compared to those whose mother's education level was greater than 9 years. Conversely, another Brazilian study failed to observe a relationship between mother's education level and ECC (Brandão *et al*., 2006).

Early childhood circumstances have been linked to adult oral health (Heilmann *et al*., 2015). Malnutrition in the early years of life is related to developmental enamel defects, mainly enamel hypoplasia and hypomineralisation, which are associated with dental caries (Psoter *et al*., 2005). In addition, early childhood malnutrition is associated with changes in salivary function with resultant reduction in salivary flow and buffering capacity, which favours caries formation (Psoter *et al*., 2005).

Socio-economic status is a major modifiable determinant of disease conditions. Thus, socio-economic status can influence certain risk factors for ECC. These risk factors include diet, oral hygiene practices, fluoride exposure and dental visits. There is no consensus on the findings of studies on socio-economic status and ECC. Some studies (Borges *et al*., 2012, Wulaerhan *et al*., 2014) established an association between socio-economic status and ECC however, others (Brandão *et al*. 2006; Naidu *et al*. 2013) failed to demonstrate a relationship. Borges *et al*. (2012) reported that Brazilian children from low socio-economic status were 1.3 times likely to develop caries compared to children from high status. Similarly, Wulaerhan *et al*. (2014) noted a significantly higher caries rate in children from low-income families. However, Brandão *et al*. (2006) and Naidu *et al*. (2013) found no link between family income and ECC in children from Sao Paulo, Brazil and Trinidad respectively. The reason for the different findings may be due to differences in the methods used to assess socio-economic status.

### 2.7 Summary

The direct evidence for MDS, which is the theoretical basis for predicting that parity has an effect on women's oral health, is lacking. There are relatively few studies on the relationship between parity and oral health, although there is substantial evidence for higher prevalences of caries in women; changes in the oral environment due to female sex hormones that promote gingivitis, periodontitis and caries; and SES and gender-based behavioural differences that may impact upon female oral health. Still the association between parity and oral health, as measured by tooth loss, caries and periodontitis, remains unclear. Most studies failed to include higher parity women and to consider confounding factors (age at first birth, duration of birth intervals, breastfeeding duration, and oral hygiene status and access to dental treatment). Therefore, in order to verify a link between parity and oral health, it is necessary to investigate populations with higher parity and to collect information on a range of biological, socioeconomic and behavioural factors that may play a role in women's responses to the stresses and demands of reproduction.

# Chapter 3

# Materials and Methods

## 3.1 Materials

### 3.1.1 Background of the study population

The Hausa are the largest subnational ethnic group in West Africa. They are a diverse but culturally homogenous people found in northern Nigeria and southeastern Niger (Smith, 1965). The majority of the Hausa live in northwestern Nigeria, an area popularly referred to as “Hausaland” (Sabiu, 2018). This ethnic group has unique cultural practices and beliefs that have been sustained over a long period (Smith, 1965).

The religion of the people is Islam and their main language is Hausa. They engage in subsistence farming, trading and artisanal specialisation in leatherworking, weaving and smithing (Sabiu, 2018). In the villages, Hausa are primarily farmers who live together in a simple system under one leader (Last, 2004). Their way of life is communal, and is guided by laws and social behaviours based primarily on Islamic teachings (Sabiu, 2018).

The majority of the families are polygamous and extended, cohabiting in large houses that include a man, his wives, his sons and their wives and children. Traditionally, Hausa women were restricted to the domestic domain from childhood (Zakaria, 2001). The society was patriarchal and polygamous with early marriage as the norm (Rehan and Abashiya, 1981; Zakaria, 2001). Today rural Hausa women engage in food processing and preparation, childcare and trade in the markets (Zakaria, 2001; Sabiu, 2018). The traditional Hausa diet consists mainly of grains (predominantly sorghum, millet, rice and maize), which are made into thick, soft sticky puddings often referred to as “tuwo” (Adegboye *et al.*, 2016). The tuwo is usually served with oil-based soup made with okra or baobab leaves and little meat. Meat is often reserved for special occasions (Adegboye *et al.*, 2016). Breakfast is often light, consisting of fried bean cakes usually served with porridge (Adegboye *et al.*, 2016).

This study was conducted among northern Hausa women, selected because of their high parity compared to women from other parts of Nigeria. Nigeria is the most populous country in Africa, with a total fertility rate of 5.7 children per woman.

However, in the northwest zone where Hausa and closely related Fulani populations are predominant, the rate is 7.3 (NPC and ICF Macro, 2009). The high fertility observed in Hausa women is attributed to a number of factors, including early marriage, teenage childbearing, polygyny, and low levels of contraceptive use (Izugbara and Ezeh, 2010). Unmarried adults are few because of the social respectability and acceptability that goes along with being married. Marriage occurs at an early age for both sexes, but earlier in girls who marry at a mean age of 13 years. (Madauci *et al.*, 1968; Tahzib, 1985; Adamu and Salihu, 2002). Teenage childbearing is highest in the northwest zone of Nigeria, at a level of 45% of 13-19 year olds. In the southwest and southeast zones of the country, the levels are 21% and 8% respectively (NPC and ICF Macro, 2009). The Islamic value placed on having children is a major driver of high fertility in the population. The religious belief of the people is that it is a sacrilege to work out the number of children to give birth to for socio-economic benefits of the family and the nation (Renne, 1996).

### 3.1.2 Sample population

The sample population was selected through a household survey in the Kumbotso Local Government Area (LGA) of Kano State, Nigeria using a multi-stage random sampling technique. Kano State is located in the northwest zone of Nigeria and has a population of 9.4 million (National Population Commission, 2006). Kumbotso LGA has its headquarters in the town of Kumbotso. It has a population of 295,979 people and covers an area of 158 $km^2$. The LGA consists of 11 administrative wards. According to the 2006 census, 66,010 women aged 15 – 65 years reside in Kumbotso LGA.

Each of the 11 wards in the LGA was given a number; these numbers were placed in a box. Six numbers were drawn at random from the box to choose the selected wards for the study. Within each ward, two communities were randomly selected using the ballot technique and all households in each community were approached. All women in the households, including widowed and divorced women who met the inclusion criteria (good general health, aged 13-80 years), were interviewed and examined. The minimum age of 13 years was used as it is the mean female age at marriage (Tahzib, 1985; Adamu and Salihu, 2002). The upper age limit of 65 years was set to 80 years to include the upper limit of parity in the community. Women with severe medical conditions, or conditions associated with xerostomia (dry mouth) such as diabetes and Sjogren's disease, as well as those who had been on antibiotics 3 to 4 weeks prior to oral examination, were excluded from the study.

*Parity groups*

The study comprised of women of all parity levels. For the case control analysis, the parity levels were separated into two basic groups: Group A, the case group, included women of high parity (5+ births). The cut point of 5 or more births was selected as it is the level where health risks and morbidity differences are seen (Simonsen *et al.*, 2005). Group B comprised of women who had given birth less than five times regardless of whether the child survived. The women in Group B served as controls and were matched by age group, general nutritional status and socio-economic status and community to those in Group A.

*Child sample*

Children less than 72 months of the selected women were included in the study to determine the effect of maternal oral health on children's dental caries experience. This group was restricted to children in good general health still residing with their mothers. Children with chronic medical conditions, and those who had been on prolonged use of sweetened medications or antibiotics three to four weeks before the study were excluded.

## 3.2 Methods

### 3.2.1 Data collection

The period of data collection was from May to July 2018.

*Data collection form for mothers*

A structured interviewer-administered questionnaire was used to obtain information on the socio-demographic status and oral health practices of the women (Appendix 2). Section A captured information on socio-demographics to address Objective 4. This includes age, educational status (none, primary, secondary, Koranic or tertiary), occupation of the current husband, occupation of the woman, age at first pregnancy and the number of children the women has given birth to as well as intervals between births. Section B elicited information on the oral health behaviour of the women. The questions cover frequency of daily consumption of refined carbohydrates between meals, frequency of tooth brushing daily, regular use of fluoridated toothpaste and frequency of dental visits.. Section C requested information on the general nutritional status of the women to address Objectives 5. The weight (kg) and height (m) of each participant was measured. Section D of the questionnaire elicited information used to address Objectives 1-6 obtained from intra oral examination of the women (described in detail below). Intra oral examination was carried out on each participant using a sterile dental mirror and probe with the participant seated on a chair in a well-lit environment.

*Data collection form for children*

A separate interviewer-administered questionnaire/form (Appendix 3) was used to collect data on the children. In most cases, the mother provided the information. This questionnaire consisted of four sections (F-J). Information from the questionnaire provided data used to address Objective 6 pertaining to the children's dental caries experience and general health. Section F captured information on the socio-demographic status of the child. This includes age, sex and father's occupation (to account for children from different marriages). Section G pertains to the oral habits of the child, with questions on the form and duration of breastfeeding during the first six month including night feeding patterns. For the purposes of this study, *exclusive breastfeeding* is when the mother gives only breast milk without any other supplement (WHO, 2001); *almost exclusive breastfeeding* is when the mother feeds the child on breast milk with water supplements; and *partial or mixed breastfeeding* is when other types of food are included with the breastfeeding. *Night-feeding practice* is defined as feeding the child at nighttime after going to bed (Folayan *et al.*, 2015). This section also involves questions on frequency of refined sugar consumption between meals in a day, frequency of tooth brushing, daily regular use of fluoridated toothpaste and frequency of visits to the dentist. Section H captured the weight and height to assess general health status. Section I included the information obtained following intra oral examination using a sterile dental mirror and probe. The number of teeth present was recorded using the Fédération Dentaire Internationale (FDI) notation. Further details on the data collection procedures and analyses are provided in the following sections.

*3.2.2 Assessment of nutritional status*

The weights of mothers and children (taken without shoes or heavy clothing) was measured to the nearest 0.1kg using a Hana Power digital scale. The height of the participants was measured to the nearest 0.1m from the heel to the uppermost part of the head using a Seca 217 stadiometer with the back and knees positioned straight and the two feet brought together with the head in the Frankfort horizontal plane (Bjelica *et al*., 2012). The Body Mass Index (BMI) of each participant was calculated as the ratio of the weight (kg) to the square of the height ($m^2$). The BMI scores of participants 13-18 years were expressed in z-scores.

*3.2.3 Assessment of socio-economic status*

The socio-economic status was scored using the Standard Occupation Classification designed by the Office of Population Census and Surveys (OPCS, 1991). The occupations were grouped into the following classes:

Social class I: professional occupations, Social class II: managerial and technical occupations, Social class III (NM): skilled occupations (non manual), Social class III (M): skilled occupations (manual), Social class IV: partly skilled occupations and Social class V: unskilled. The social classes I and II were grouped as high socio-economic status, classes III (NM) and III (M) as middle, and classes IV and V as low socio-economic status.

*3.2.4 Assessment of oral hygiene status*

Oral hygiene status of the mothers and children was evaluated using the Simplified Oral Hygiene Index (OHI-S) of Greene and Vermillion (1964). The index comprises of debris and calculus scores on selected tooth surfaces. The buccal and lingual surfaces of the six index permanent teeth were examined (FDI numbers 11, 16, 26, 31, 36, 46). In children who were yet to emerge the index permanent teeth, the facial and lingual surfaces of the following six index teeth (FDI numbers 51, 55, 65, 71, 75, 85) were examined. Oral hygiene was classified as *good*, *fair*, or *poor* when score ranges were 0.0 – 1.2, 1.3 – 3.0, and >3.0 respectively.

*3.2.5 Assessment of tooth loss in women*

The teeth present were recorded, with the exclusion of the third molars, using the Fédération Dentaire Internationale (FDI) notation. All the teeth missing in the mouth, irrespective of the loss aetiology, were recorded separately and a total score was generated for each participant. History of the missing tooth was elicited from the participants to exclude agenesis, trauma and other causes.

*3.2.6 Assessment of dental caries in women*

The DMFT index of the World Health Organization for dental epidemiological studies was used to determine the caries status of the participants (WHO, 1997). The index includes the following: D - number of decayed teeth, M – number of extracted teeth due to caries, F- number of teeth filled or crowned due to caries and T – teeth present. The DMFT score is a sum of the number of decayed, missing and filled teeth due to caries. Only teeth extracted due to caries were recorded as missing.

*3.2.7 Assessment of periodontal status in women*

Periodontal status was assessed using the Community periodontal Index (CPI). A lightweight periodontal probe with a 0.5 mm ball tip with graduated markers was used for the assessment, which was performed on ten index teeth (17, 16, 11, 26, 27, 47, 46, 31, 36, 37) and 6 sextants (17–14, 13–23, 24–27, 38–34, 33–43, 44–47) were assessed per participants (Dhingra and Vandana, 2011). Each index tooth was assessed at 2 sites (buccal and lingual) and each sextant was scored according to its highest CPI score. If no index tooth was present in a sextant, all the remaining teeth in that sextant were examined and the highest score was recorded as the score for that sextant. The CPI scores range from code 0-4 with scores as follows: 0- healthy periodontal status, 1- bleeding on probing, 2- calculus detected on probing, 3- periodontal pockets 4-5mm and 4- periodontal pockets $\geq$6mm.

*3.2.8 Assessment of dental caries in children*

Child caries was recorded using the WHO (1997) dmft index where d = deciduous teeth number of decayed teeth, m = number of extracted teeth due to caries, f = number of teeth filled or crowned due to caries and t = teeth present. The dmft score is a sum of the number of decayed, missing and filled teeth due to caries. Where any permanent teeth have erupted, the DMFT was used. Only teeth extracted due to caries were recorded as missing. In cases of mixed dentitions, a combination of the two indices was used.

In order to make the intra oral examination of child participants a pleasant experience, the principal investigator used the “Tell show do” method (Farhat-McHayleh *et al*., 2009). This involves explaining in simple terms what is to be done, showing the participants how it is done and then performing the examination. The principal investigator and the two female examiners performed intra oral examinations on each other to allay the fears of the participants and to make them see that it is a pain-free exercise.

*3.2.9 Assessment of women’s beliefs on parity and tooth loss*

A grounded theory approach that involved in-depth focus-group discussions (FGDs) was conducted as part of the investigation of the effect of parity and socio-behavioural factors on tooth loss. The use of FGDs is a methodologically sound approach to collecting qualitative data (Strauss and Corbin, 1998).

A purposive selection of women for FGDs was made from the participant sample. The total group consisted of 33 women aged 19-66 years. Women of all parity levels were included and selected to represent broad age cohorts of 19-30 years, 31-45 years and 46-66 years. Each age group consisted of an average of six women. Two FGD sessions were conducted per age cohort.

Trained bilingual Hausa and English-speaking married women with previous experience in qualitative interviewing, along with the principal investigator, conducted the FGDs. The use of local Muslim Hausa women as field workers facilitated access to women in seclusion, promoted openness among the women during the FGDs, and minimized the objections and suspicions of the husbands of the participants. The local field workers were not assigned to groups in their own areas.
The FGDs were designed to obtain responses to queries on the following topics: causes of tooth loss, effects of tooth loss on the quality of women’s lives, gender and tooth loss, issues regarding parity and tooth loss, and cultural beliefs on parity and tooth loss. All interviews were taped, transcribed, and translated verbatim from Hausa

into English. Two Hausa-language teachers at Bayero University, Kano and two Hausa speaking dentists (also from Kano State and not involved in the study) supervised the transcription and translation.

## 3.3 Data analysis

### *3.3.1 Sample size determination*

For the quantitative portion of the study, seven age cohorts of women were sampled covering the ages 13-80 years (13-17, 18-27, 28-37, 38-47, 48-57, 58-65, $\geq$ 66). Sample size calculation for case control studies using Epitool epidemiological calculators (Dean *et al*., 2014) was used to determine sample size based on the prevalence of tooth loss (10%) in northwestern Nigeria (Esan *et al*., 2010), an odds ratio of 10 and at the power of 90 for each age cohort. A sample size of 34 was calculated for the case group for each age cohort, for a total minimum of 204 high parity women. A purposive minimum sample of 204 low parity women, matched by age and socio-economic status, was selected from the same population.

### *3.3.2 Data analysis for parity and tooth loss*

The data were statistically analyzed using SPSS (version 16) software for Windows. Analysis included all women at the different levels of parity as well as the children. Descriptive analyses of age, nutritional status, socio-economic status, parity, behavioral factors (such as frequency of tooth brushing per day, use of fluoridated toothpaste and consumption of refined sugar) were done. Correlation analysis was done between parity and tooth loss for the high and low parity groups. Analysis of multiple variance (ANOVA) was used to compare mean tooth loss across the different parity levels. Comparative analyses such as independent Student’s t-tests were used to compare the mean tooth loss between extremes of parity and also between women of low and high parity.

To determine the effect of parity on maternal caries, the mean DMFT score was analyzed. The mean DMFT score of the different levels of parity and between low and high parity groups was compared using ANOVA and Student’s t-tests respectively. Correlation analysis was done between parity as well as maternal mean DMFT score. Furthermore, the association between mean periodontal attachment loss and parity was determined using correlation.

Multiple regression analyses were used to test the association between the independent variables (demographic and reproductive parameters and oral hygiene status) and the outcome variables (caries, periodontitis and tooth loss respectively). All independent variables were modeled against the outcome variables. The selection of the most important predictors was based on biological plausibility and current knowledge regarding reproduction and caries, periodontitis and tooth loss. Association between maternal dental caries and dental caries in the children was determined using regression analysis. The mean dmft score of the children was regressed against maternal caries risk factors. Statistical significance was inferred at $p<0.05$.

*3.3.3 Data analysis for FGDs*

The principles of grounded theory data analysis (Strauss and Corbin, 1998; Creswell and Poth, 2017) were used. Codes were generated from the text documents, which involved identification of potential useful concepts. Constant comparisons of concepts were done. Similar concepts were pooled together, and relationships between concepts explored to evolve categories. The categories that emerged from the coding were linked together in a theoretical model around a central category. There was alertness to negative instances, with each subsequent transcript, negative cases and pieces of data that challenged the emerging model examined, and the emerging model suitably adjusted to include the full range of variations found in the transcript. During the development of categories, axial coding was expanded by writing comments on the quotations, and interesting connections between quotations were noted using hyperlinks and the network diagrams to draw and visualize relationships. At the end of the analysis, two major theoretical categories were generated around perceptions on the assumptions and beliefs attached to childbearing and tooth loss in women and the causes of tooth loss and its effects on women of childbearing age.

Network diagrams were created using the network view function of ATLAS.ti to show the relationship between the categories and to display the models to explore the data and visualize the ideas and findings (Muhr, 1994). Illustrative direct quotations were drawn from the text to highlight key findings.

### 3.4 Pilot study

The questionnaire was pretested on 10 parous women who resided in the selected communities. For the intra oral examinations, the principal investigator and two female dentists fluent in both English and Hausa were calibrated on the assessment of dental caries and periodontal attachment loss. After a week, the principal investigator repeated the examinations. The intra-observer and inter-observer reliability was calculated using the Cohen’s kappa statistic (Cohen, 1968).

### 3.5 Ethical consideration

Ethical clearance for the study was obtained from the Ethics and Research committee of the Obafemi Awolowo University, Ile-Ife, Osun State, Nigeria (IPHOAU/12/717) (Appendix 3) and the Health Sciences Research Ethics Committee of the University of the Witwatersrand, Johannesburg (M170343) (Appendix 4). Local village leaders gave permission to conduct the study. A male local assistant who spoke Hausa fluently was employed to facilitate links with village leaders and husbands of the women. Informed consent was obtained from the husbands of married women living with their husbands. Written informed consent was obtained from each participant. The consent form was translated into Hausa and read to participants who were illiterate. Women who were illiterate and were willing to participate in the study thumb printed on the consent form. Only women who were willing to participate and gave informed consent were included. Only children whose parents gave informed consent participated in the study.

### 3.6 Community engagement oral health prevention measures

Basic oral treatment such as scaling and polishing, atraumatic restorative treatment (ART), oral urgent treatment (OUT) of participants with caries, toothache and odontogenic infections was carried out for all participants. All family members were trained on tooth brushing methods. Mothers were encouraged to develop leadership skills and to take responsibility for the daily tooth brushing activity in the family.

# Chapter 4

# Results

## Part 1: Quantitative study

### 4.1 Socio-demographic characteristics of study participants

Six hundred and thirty five women participated in the study. Their ages ranged from 13 to 80 years with a mean age of 32.19±12.72 years (**Figure 4.1**). The majority (65.1%) of the participants were between the ages of 18 and 37 years. The extremes of the age cohorts had the least number of participants, with 5.4% aged 13-17 years and 1.7% aged ≥66 years.

Approximately 5% of the participants were illiterate. The level of general education was low with 22% of women having attended primary school and 0.5% with some tertiary education (**Figure 4.2**). Secular education is expensive compared to religious institutions and few families can afford to pay the fees. More than 50% of the women had the form of education referred to as *Islamiyyah* schooling where the emphasis is on Koranic learning.

Determination of socio-economic status for the women was complicated by the multi-household structure of families. For this reason we focused on women's work alone for the scoring. According to their individual status, the majority (64.9%) of the participants were of middle socio-economic status and supported themselves working as market traders of cereal grains and legumes (soya beans, millet and other beans). The remaining 35.1% were housewives of low socio-economic status with no outside employment. There were no women of high socio-economic status (**Figure 4.3**).

The socio-economic status varies significantly by age in the population. The age cohort 13-17 years had the highest proportion (55.9%) of low socio-economic status individuals while women aged 66 years and above constituted the majority (81.8%) of those in the middle socio-economic status (Likelihood ratio $\chi^2$ = 20.78, p=0.00) (**Table 4.1**).

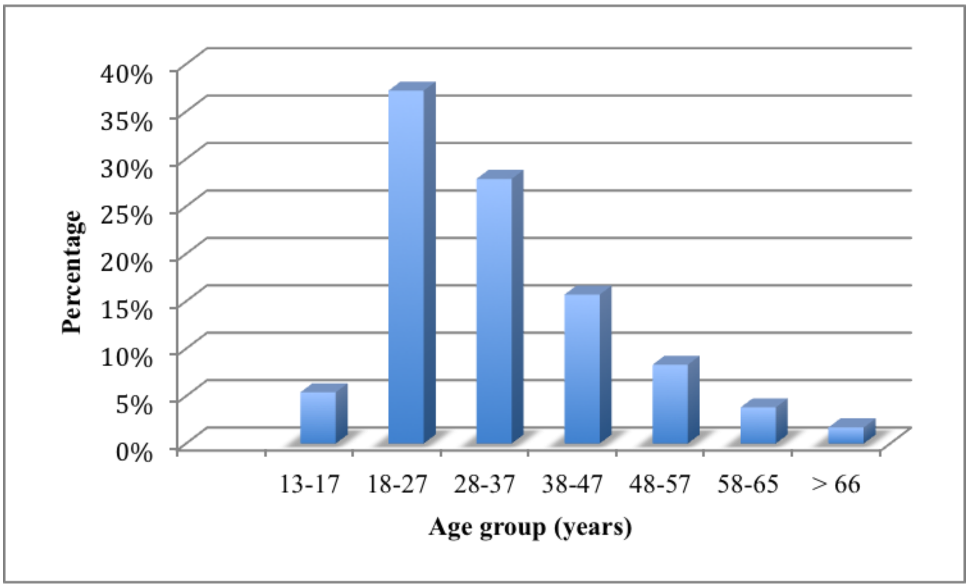


**Figure 4.1 Distribution of participants by age group (years)**

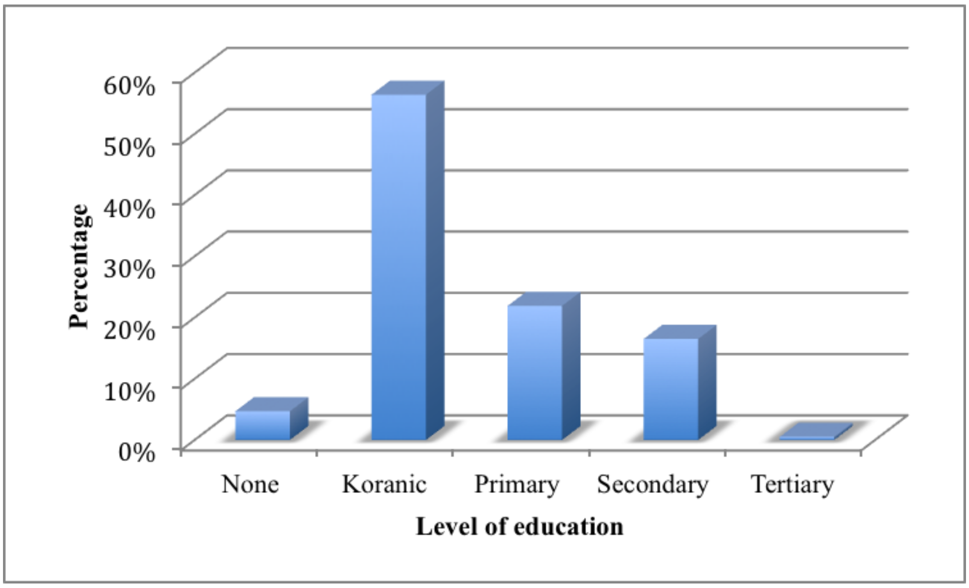


**Figure 4.2 Distribution of participants by level of education**

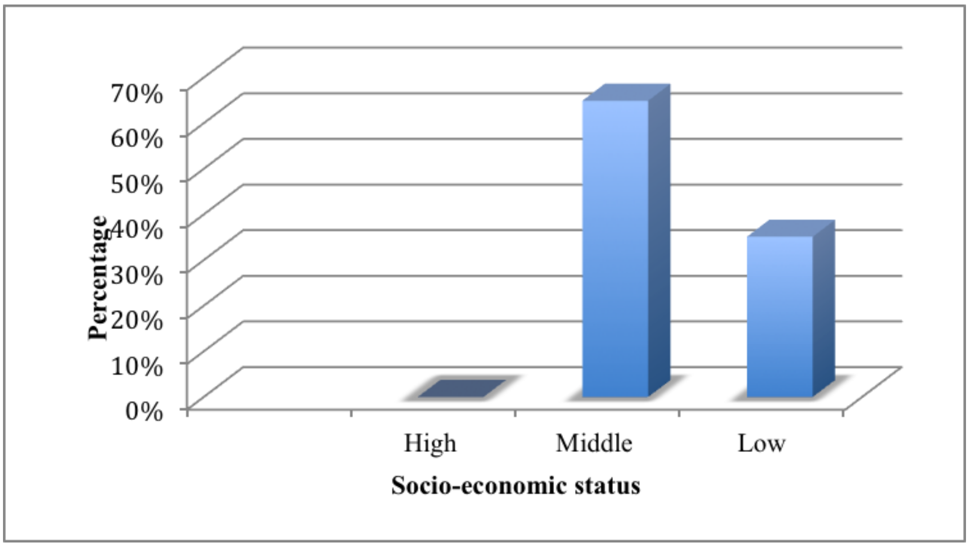


**Figure 4.3 Socio-economic distributions of the participants**

**Table 4.1 Socio-economic status by age cohort**

| Age group (Years) | SES | | Total N (%) |
|---|---|---|---|
| | Middle N (%) | Low N (%) | |
| 13-17 | 15 (44.1%) | 19 (55.9%) | 34 (100.0%) |
| 18-27 | 138 (58.5%) | 98 (41.5%) | 236 (100.0%) |
| 28-37 | 121 (68.4%) | 56 (31.6%) | 177 (100.0%) |
| 38-47 | 76 (76.0%) | 24 (24.0%) | 100 (100.0%) |
| 48-57 | 39 (73.6%) | 14 (26.4%) | 53 (100.0%) |
| 58-65 | 14 (58.3%) | 10 (41.7%) | 24 (100.0%) |
| ≥ 66 | 9 (81.8%) | 2 (18.2%) | 11 (100.0%) |
| **Total** | **412 (64.9%)** | **223 (35.1%)** | **635 (100.0%)** |

### 4.2 Reproductive parameters of participants

About 8% of the women were nulliparous, with the majority of these (83%) in the youngest age cohort. The remaining childless women were in the age groups 28-37 years (8.5%) and above 47 years (8.5%). As expected, parity varies proportionally to increasing age in the sample. The highest parity of 17 children was observed for a woman in the age group 58-65 years. There were increasing proportions of women with more than four children between the ages of 28 and 47 years. Above 37 years, few women had less than four children or greater than 10 children. Thirty-one women (4.9%) had ten or more children and they were aged between 28 and 65 years (**Table 4.2 and Figure 4.4**).

There were more women in the low parity group ($\leq$4 children) compared to the high parity group ($\geq$5 children) (55.7% and 44.3% respectively). The overall mean parity was 4.33±3.04 children per woman or just below the standard definition of high parity. Considering mean parity by age cohorts, those participants aged 13-17 years had the lowest mean parity of 0.68±0.91 while the highest mean parity (7.21±3.70) characterized the oldest women aged between 58 and 65 years (**Tables 4.2** and **4.3**).

The age at first birth is relatively young. The majority of the participants (72.2%) had their first child before 19 years of age. Half of those aged 13-17 had already given birth, and one had four children before age 18. The age at last birth, while less informative as many participants had not completed their reproductive years, suggests that most women are reproductively active for periods of 20 years or more (**Tables 4.2** and **4.4**).

Other reproductive parameters that provide information relating to maternal stress are the mean birth interval (24.11±8.52 months) and the duration of breastfeeding. **(Table 4.3).** The birth intervals were quite variable, yet the mean of approximately two years was short given that breastfeeding continues for at least one year and up to 5 years (mean of 19.78±2.77 months). These data suggest that many women are breastfeeding one child while gestating another.

These reproductive characteristics reflect the predominance of younger women in the sample as well as the importance of pronatalism in the traditions of the Hausa people.

**Table 4.2 Parity by age cohort**

| Age (years) | Parity | | | | | | | | | | | | | | | | | Mean ± SD | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **0** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **17** | | |
| 13-17 | 17 | 14 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.68 ± 0.91 | **34** |
| 18-27 | 22 | 65 | 46 | 48 | 29 | 20 | 3 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2.36 ± 1.59 | **236** |
| 28-37 | 4 | 9 | 15 | 13 | 28 | 34 | 19 | 21 | 18 | 9 | 5 | 1 | 1 | 0 | 0 | 0 | 0 | 5.19 ± 2.47 | **177** |
| 38-47 | 0 | 0 | 6 | 5 | 12 | 11 | 10 | 20 | 11 | 16 | 4 | 1 | 2 | 1 | 0 | 1 | 0 | 6.65 ± 2.58 | **100** |
| 48-57 | 1 | 1 | 1 | 4 | 3 | 10 | 5 | 7 | 5 | 7 | 4 | 1 | 2 | 2 | 0 | 0 | 0 | 6.79 ± 2.94 | **53** |
| 58-65 | 1 | 0 | 0 | 1 | 1 | 6 | 4 | 3 | 1 | 1 | 2 | 1 | 1 | 0 | 1 | 0 | 1 | 7.21 ± 3.70 | **24** |
| ≥66 | 2 | 0 | 0 | 2 | 1 | 1 | 2 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4.64 ± 2.94 | **11** |
| **Total** | **47** | **89** | **69** | **74** | **75** | **82** | **43** | **54** | **38** | **33** | **15** | **4** | **6** | **3** | **1** | **1** | **1** | **4.33 ± 3.04** | **635** |

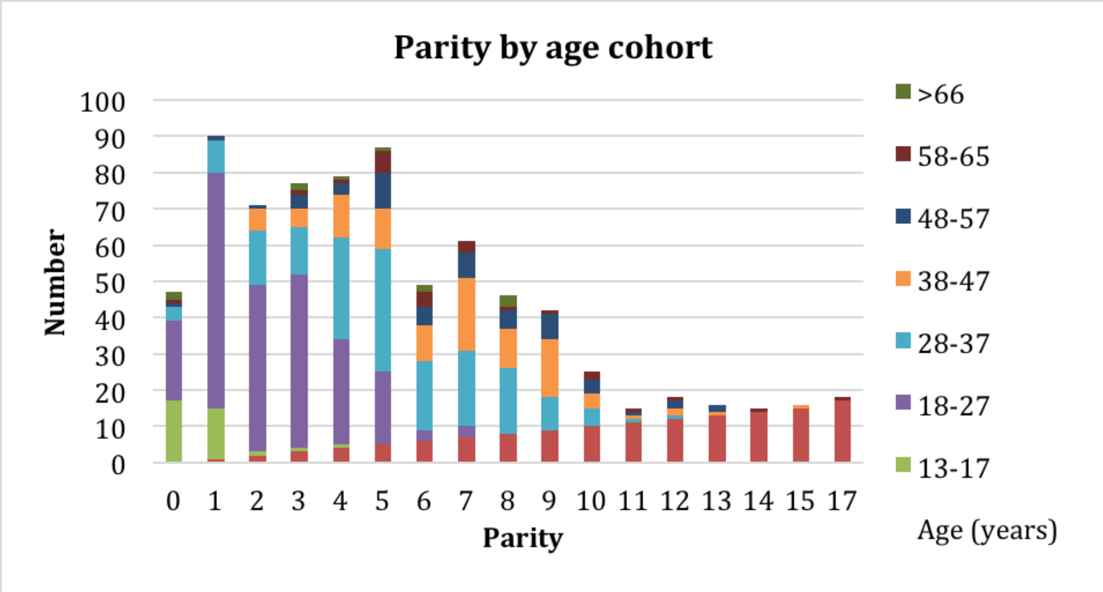

**Figure 4.4 Parity by age cohort**

**Table 4.3 Descriptive statistics: reproductive parameters**

| Reproductive parameters | N | Mean ± SD | Range |
|---|---|---|---|
| Parity | 635 | 4.33 ± 3.04 | 0-17 |
| Age at first birth (years) | 576 | 17.59 ± 3.45 | 11-40 |
| Age at last birth (years) | 575 | 27.73 ± 7.88 | 13-50 |
| Birth intervals (months) | 478 | 24.11 ± 8.52 | 12-108 |
| Duration of breastfeeding (months) | 548 | 19.78 ± 2.77 | 12-60 |

**Table 4.4 Reproductive parameters by age at first and last birth**

| **Age at first birth (years)** | **N (%)** |
|---|---|
| ≤ 18 | 431 (72.2%) |
| 19-24 | 133 (22.3%) |
| 25-29 | 18 (3.0%) |
| ≥ 30 | 15 (2.5%) |
| **Age at last birth (years)** | |
| ≤ 24 | 231 (38.6%) |
| 25-29 | 118 (19.8%) |
| 30-34 | 102 (17.1%) |
| ≥ 35 | 146 (24.5%) |

### 4.3 Oral health practices of participants

The oral hygiene status of the participants, as determined by the OHI-S score, was generally poor. Four hundred and twenty four (66.8%) had poor, 30.7% had fair, and only 2.5% had good oral hygiene **(Table 4.5).** There was great diversity in the oral hygiene practices. The majority of the women (52.4%) responded that they cleaned their teeth more than twice daily, followed by those who cleaned twice daily (33.5%). Only a few women (1.9%) reported that they did not clean their teeth. The tools used for cleaning varied greatly. The majority of participants (65.5%) used toothbrushes with toothpaste (61.9% of which was fluoridated). Traditional chewing sticks were employed by 7.9%. Use of hand and water (13.1%) and other substances including charcoal and soap (8.3%) were also reported. The high frequency of cleaning reflects the religious observances (ablution before prayer) of the Hausa people.

**Table 4.5 Oral hygiene status and practices**

| **Variables** | **N (%) (Total N=635)*** |
|---|---|
| **Oral hygiene status** | |
| Good | 16 (2.5%) |
| Fair | 195 (30.7%) |
| Poor | 424 (66.8%) |
| **Tooth cleaning tools** | |
| Toothpaste and toothbrush | 416 (65.5%) |
| Chewing stick | 50 (7.9%) |
| Hand and water | 83 (13.1%) |
| Hand and salt | 26 (4.1%) |
| Cotton wool and salt | 1 (0.2%) |
| Other | 53 (8.3%) |
| **Frequency of tooth cleaning** | |
| I don’t brush | 12 (1.9%) |
| Once daily | 77 (12.1%) |
| Twice a day | 213 (33.5%) |
| >Twice a day | 333 (52.4%) |
| **Fluoride in toothpaste** | |
| Yes | 393 (61.9%) |
| No | 242 (38.1%) |

*Some participants did not respond to the questions

A significant difference was observed in the oral hygiene status according to the socio-economic status **(Table 4.6)**. There were more women of low socio-economic status with good oral hygiene compared to middle socio-economic status (56.2% vs. 43.8% respectively). However, more women from the middle socio-economic status had fair or poor oral hygiene compared to those of lower socio-economic status (68.2% vs. 31.8% respectively)**.**

**Table 4.6 Oral hygiene status by socio-economic status**

| Oral hygiene status | Middle SES N (%) | Low SES N (%) | Total N (%) | p-value |
|---|---|---|---|---|
| Good | 7 (43.8%) | 9 (56.2%) | 16 (100.0%) | 0.02* |
| Fair | 116 (59.5%) | 79 (40.5%) | 195 (100.0%) | |
| Poor | 289 (68.2%) | 135 (31.8%) | 424 (100.0%) | |
| **Total** | **412 (64.9%)** | **223 (35.1%)** | **635 (100.0%)** | |

*Pearson $\chi^2$ =7.63, p=0.02

A large proportion of the women (92.3%) had never visited a dentist. However, the proportion of women who visited the dentist did not differ by socio-economic status using a Chi-square test (p>0.05) (**Table 4.7**). Cultural practices among the Hausa people, which involve restrictions on the movement of women outside the home except when accompanied by a male family member, may underlie the observed low level of dental visits.

**Table 4.7 Dental visit by socio-economic status**

| | Dental visit | | |
|---|---|---|---|
| Socio-economic status | Yes N (%) | No N (%) | Total N (%) |
| Middle | 32 (7.8%) | 380 (92.2%) | 412 (100.0%) |
| Low | 17 (7.6%) | 206 (92.4%) | 223 (100.0%) |
| **Total** | **49 (7.7%)** | **586 (92.3%)** | **635 (100.0%)** |

p=0.95

## 4.4 Sugar consumption and BMI status of participants

*4.4.1 Sugar consumption between meals*

The reported frequencies of refined sugar consumption between meals, in general and during pregnancy, were low (**Tables 4.8**). Consumption of sugar between meals was not the regular practice reported by most women. During pregnancy, the majority (63.8%) rarely consumed refined sugar, and fewer women appeared to consume sugar between meals. These results reflect the low availability and affordability of refined sugar in rural areas. However, these data are not informative regarding whether quantities of sugar varied for consumers during pregnancy. In addition, the sugar content of beverages consumed between meals was not considered.

**Table 4.8 Frequency of refined sugar consumption**

| **Variables** | **N (%) (N=635)** |
|---|---|
| **Frequency of sugar consumption between meals** | |
| Always | 61 (9.6%) |
| Sometimes | 303 (47.7%) |
| Rarely | 271 (42.7%) |
| **Frequency of sugar consumption between meals during pregnancy** | |
| Always | 43 (6.8%) |
| Sometimes | 187 (29.4%) |
| Rarely | 405 (63.8%) |

*4.4.2 BMI status*

Generally, the sample population was characterized by normal BMI values. Twenty-two percent of the women were overweight/obese, with the majority of those (45.5%) aged $\geq$ 66 years. The largest grouping of the underweight individuals (11.8% of the total sample) were in the youngest age cohort of 13-17 years (**Table 4.9)**. It is not unexpected that the BMI status of the women varies proportionally with increasing age, as that is the general trend for women across populations and for women in the age range of our sample.

**Table 4.9 BMI status of total sample**

| Age group (years) | BMI categories | | | Total N (%) |
|---|---|---|---|---|
| | Underweight N (%) | Normal N (%) | Overweight/obese N (%) | |
| 13-17 | 7 (20.6%) | 25 (73.5%) | 2 (5.9%) | 34 (100.0%) |
| 18-27 | 36 (15.3%) | 169 (71.6%) | 31 (13.1%) | 236 (100.0%) |
| 28-37 | 13 (7.3%) | 115 (65.0%) | 49 (27.7%) | 177 (100.0%) |
| 38-47 | 14 (14.0%) | 61 (61.0%) | 25 (25.0%) | 100 (100.0%) |
| 48-57 | 3 (5.7%) | 30 (56.6%) | 20 (37.7%) | 53 (100.0%) |
| 58-65 | 3 (12.5%) | 13 (54.2%) | 8 (33.3%) | 24 (100.0%) |
| $\geq$ 66 | 0 (0.0%) | 6 (54.5%) | 5 (45.5%) | 11 (100.0%) |
| **Total** | **75 (11.8%)** | **420 (66.1%)** | **140 (22.0%)** | **635 (100.0%)** |

The mean BMI scores for underweight, normal and overweight/obese were 17.39$\pm$0.99, 21.47$\pm$1.58 and 28.70$\pm$3.69 respectively. There was significant variation in the mean BMI scores (F=817.25, p=0.00). Post hoc testing with Games-Howell multiple comparisons of means revealed statistically significant differences between the three BMI categories (p=0.00) **(Table 4.10)**.

**Table 4.10 Mean BMI values**

| BMI Categories | N (635) | Mean $\pm$ SD | Significance |
|---|---|---|---|
| Underweight[a] | 75 | 17.39 $\pm$ 0.99 | F=817.25 |
| Normal[b] | 420 | 21.47 $\pm$ 1.58 | p=0.00* |
| Overweight/obese[c] | 140 | 28.70 $\pm$ 3.69 | |

Post hoc analysis
Significant – ab, ac, bc

The BMI status of the participants varied significantly by parity group (Likelihood ratio $\chi^2$=12.01, p=0.00) using the Chi-square test. There were more underweight women in the low parity group compared to the high parity group (68.0% vs. 32.0% respectively), whereas there were more overweight/obese women in the high parity group compared to the low parity group (55.7% vs. 44.3%) **(Table 4.11)**. This suggests that there is a positive association between parity and BMI status of the women.

**Table 4.11 BMI status by parity group**

| BMI Categories | Low parity N (%) | High parity N (%) | Total N (%) | p-value |
|---|---|---|---|---|
| Underweight | 51 (68.0%) | 24 (32.0%) | 75 (100.0%) | 0.00* |
| Normal | 241 (57.4%) | 179 (42.6%) | 420 (100.0%) | |
| Overweight/Obese | 62 (44.3%) | 78 (55.7%) | 140 (100.0%) | |
| **Total** | **354 (55.7%)** | **281 (44.3%)** | **635 (100.0%)** | |

Likelihood ratio $\chi^2$=12.01, p=0.00

Interestingly, the BMI status of the women did not differ by socio-economic status. There were more overweight/obese women in the middle SES (23.8%) compared to the low SES (18.8%), yet this was not statistically significant using a Chi-square test (Likelihood ratio $\chi^2$=2.81, p=0.23) **(Table 4.12)**. This trend may reflect that women of middle SES are older and have access to more resources.

**Table 4.12 BMI status by socio-economic class**

| BMI Categories | Middle SES N (%) | Low SES N (%) | Total N (%) | p-value |
|---|---|---|---|---|
| **Underweight** | 44 (10.7%) | 31 (13.9%) | 75 (100.0%) | 0.23 |
| **Normal** | 270 (65.5%) | 150 (67.3%) | 419 (100.0%) | |
| **Overweight/Obese** | 98 (23.8%) | 42 (18.8%) | 140 (100.0%) | |
| **Total** | **412 (64.9%)** | **223 (35.1%)** | **635 (100.0%)** | |

Likelihood ratio $\chi^2$=2.81 p=0.23

There is no discernible pattern in the frequency of refined sugar consumption between meals based on BMI status (**Table 4.13**). A similar proportion of women across the BMI categories rarely consumed sugar between meals and the ‘always’ consumers were also fairly evenly distributed. This suggests that the levels of overweight and obesity are not influenced by the frequency of refined sugar intake between meals.

**Table 4.13 BMI status by frequency of refined sugar intake**

| Frequency of sugar intake | BMI Categories | | | Total N (%) |
|---|---|---|---|---|
| | Underweight N (%) | Normal N (%) | Overweight/ Obese N (%) | |
| Always | 7 (9.3%) | 37 (8.8%) | 17 (12.1%) | 61 (9.6%) |
| Sometimes | 36 (48.0%) | 207 (49.3%) | 60 (42.9%) | 303 (47.7%) |
| Rarely | 32 (42.7%) | 176 (41.9%) | 63 (45.0%) | 271 (42.7%) |
| **Total** | **75 (100.0%)** | **420 (100.0%)** | **140 (100.0%)** | **635 (100.0%)** |

## 4.5 Relationship between parity and caries experience, including the investigation of possible confounders

### *4.5.1 Association between reproductive parameters and caries*

Caries experience (presence/absence) among the participants was relatively high with an overall prevalence of 41.4%. The caries experience differed by parity with more caries-free women observed in the low parity levels ($\leq$4). Among these, women with only one child were the most caries-free (82%). Interestingly, at parity 5, there was no difference in the proportion of women who were caries-free and caries-active (both at 50%). However, from parity 6 and above, the frequency of caries experience was higher except at parity 8. Women with nine or more children had the highest proportion of caries presence (60.9%) (**Table 4.14**).

**Table 4.14 Frequency of caries by parity and parity groups**

| Parity | N | Caries absent N (%) | Caries present N (%) |
|---|---|---|---|
| 0 | 47 | 30 (63.8) | 17 (36.2) |
| 1 | 89 | 73 (82.0) | 16 (18.0) |
| 2 | 69 | 44 (63.8) | 25 (36.2) |
| 3 | 74 | 50 (67.8) | 24 (36.2) |
| 4 | 75 | 46 (61.3) | 29 (38.7) |
| 5 | 82 | 41 (50.0) | 41 (50.0) |
| 6 | 43 | 20 (46.4) | 23 (53.5) |
| 7 | 54 | 22 (40.7) | 32 (51.3) |
| 8 | 38 | 21 (55.3) | 17 (44.7) |
| ≥9 | 64 | 25 (39.1) | 39 (60.9) |
| **Parity group** | | | |
| Low | 354 | 243 (68.6) | 111 (45.9) |
| High | 281 | 129 (45.9) | 152 (54.1) |
| **Total** | **635** | **372 (58.6)** | **263 (41.4)** |

These general descriptive results for caries presence/absence suggest that the caries experience of the women was potentially influenced by parity. To verify this, it is necessary to examine caries and parity in greater detail using DMFT scores and controlling for age and other potential confounders.

DMFT scores provide more information regarding the differences in caries severity. The scores ranged from 0 to 26 with an overall mean value of 1.23±2.42. Although the prevalence of caries of over 40% was high, the overall mean DMFT score of 1.23±2.42 (Table 4.17) was very low according to the WHO standard of mean DMFT index (very low <5.0, low 5.0-8.9, moderate 9.0-13.9 and high >13.9) (Petersen *et al.*, 2005). Although some women have individual scores that are extremely high, there is considerable variation as indicated by the large standard deviations (**Table 4.15**). Table 4.15 also shows the relationship between reproductive parameters (parity group, age at first birth, duration of reproduction and interbirth intervals) and mean DMFT score. Parity group (low vs. high) was found to be significantly associated with caries experience (p=0.00) using the Student's t-test analysis. The mean DMFT score for the high parity group was significantly higher than the low parity group (**Table 4.15**). Age at first birth was not associated with the mean DMFT score. The scores differ considerably across the groups but there is no consistent pattern and the standard deviations are large except for those women first giving birth at age 30 and older.

The mean DMFT score varies with increasing duration of reproductive years. Women reproductively active for $\leq$5 years had the lowest caries experience of 0.61$\pm$1.27, while those with 18 years or more had the highest mean score (2.22$\pm$3.51). The overall trend was similar for interbirth intervals. Post hoc analysis with Games-Howell multiple comparisons of means revealed a statistically significant difference between mean DMFT scores and duration of reproduction (F=14.93 p=0.00) but not between mean DMFT scores and interbirth intervals (**Table 4.15**). These results are expected because the duration of reproduction is very much related to age.

**Table 4.15 Mean DMFT scores by reproductive parameters**

| Covariates | N | Mean $\pm$ SD | Significance |
|---|---|---|---|
| **Parity group** | | | |
| Low parity $\leq$4 | 354 | 0.79 $\pm$ 1.56 | t= -5.25 |
| High parity $\geq$5 | 281 | 1.78 $\pm$ 3.09 | p= 0.00* |
| **Age at first birth** | | | |
| $\leq$18 | 431 | 1.21 $\pm$ 2.45 | F= 0.76 |
| 19-24 | 133 | 1.44 $\pm$ 2.66 | p= 0.56 |
| 25-29 | 18 | 1.17 $\pm$ 1.79 | |
| $\geq$30 | 15 | 0.40 $\pm$ 0.63 | |
| **Duration of reproduction** | | | |
| $\leq 5^{a}$ | 222 | 0.61 $\pm$ 1.27 | F= 14.93 |
| $6\text{-}11^{b}$ | 158 | 0.95 $\pm$ 1.47 | p= 0.00* |
| $12\text{-}17^{c}$ | 126 | 1.63 $\pm$ 3.08 | |
| $\geq 18^{d}$ | 129 | 2.22 $\pm$ 3.51 | |
| **Inter birth interval** | | | |
| <3 | 505 | 1.12 $\pm$ 2.23 | F= 2.42 |
| 3-5 | 112 | 1.61 $\pm$ 3.05 | p= 0.90 |
| $\geq$6 | 18 | 1.78 $\pm$ 2.77 | |
| **Overall mean** | 635 | 1.23 $\pm$ 2.42 | |

Post hoc analysis
Significant – ac, ad, bd

The mean DMFT score varies proportionally to increasing age in both parity groups but the trend is most clear for the high parity group (**Table 4.16**). The highest mean DMFT score for that group was 3.17±2.93 observed in women aged ≥66 years, while in the low parity group it was 2.80±2.77 for the same age group. The lowest mean DMFT scores for the parity groups were 0.46±0.86 and 0.50±1.05, observed in those high parity women aged 18-27 and low parity 13-17 year olds respectively. Women with high parity experienced more caries than those with low parity in all age cohorts except 18-27 years. However, this difference was not statistically significant ($p>0.05$) based on the Student's t-test analysis (**Table 4.16**). This result is due to the wide standard deviations.

**Table 4.16 Mean DMFT scores by parity group**

| Age group (years) | Low parity ≤4 | | High parity ≥5 | | p-value |
|---|---|---|---|---|---|
| | N (354) | Mean ± SD | N (281) | Mean ± SD | |
| 13-17 | 34 | 0.50 ± 1.05 | 0 | - | - |
| 18-27 | 210 | 0.54 ± 1.13 | 26 | 0.46 ± 0.86 | 0.72 |
| 28-37 | 69 | 1.09 ± 1.94 | 108 | 1.45 ± 2.65 | 0.33 |
| 38-47 | 24 | 1.71 ± 2.68 | 77 | 1.75 ± 2.37 | 0.96 |
| 48-57 | 9 | 1.44 ± 1.88 | 43 | 2.67 ± 4.06 | 0.30 |
| 58-65 | 3 | 1.67 ± 2.08 | 21 | 3.00 ± 5.70 | 0.70 |
| ≥66 | 5 | 2.80 ± 2.77 | 6 | 3.17± 2.93 | 0.84 |

Mean DMFT scores differed by parity level. Women with only one child had the lowest mean score of 0.33 while those with nine or more children had the highest score of 2.92. There is an apparent trend of increase in mean DMFT score from parity 5 and above, although there was a reduction for the smaller sample of parity 8. The correlation between parity and mean DMFT score is statistically significant using a Spearman's Rho non-parametric test ($\rho=0.81$, $p=0.01$). Parity is positively correlated with caries experience in the Hausa women **(Table 4.17).**

**Table 4.17 Correlation analysis between parity and mean DMFT score**

| Parity | N | Mean DMFT score | |
|---|---|---|---|
| 0 | 47 | 0.97 | ρ=0.81 |
| 1 | 89 | 0.33 | p=0.01* |
| 2 | 69 | 0.99 | |
| 3 | 74 | 0.84 | |
| 4 | 75 | 0.97 | |
| 5 | 82 | 1.34 | |
| 6 | 43 | 1.33 | |
| 7 | 54 | 1.96 | |
| 8 | 38 | 1.08 | |
| ≥ 9 | 64 | 2.92 | |

*4.5.2 Association between socio-demographic variables and mean DMFT scores*

The participant's caries experience varied by age, socio-economic status and level of education. Post hoc analysis with Games-Howell multiple comparisons of means showed that the mean DMFT scores differed significantly by age cohorts (F=10.37, p=0.00), with the variation most characteristic of the extremes of the age groups (13-17 vs. ≥66 years)**.** However**,** the mean DMFT scores are not significantly associated with socio-economic status or level of education using Student's t-test (p>0.05 respectively) **(Table 4.18)**.

This reflects the homogenous character of the sample population; there was little difference in the SES and educational attainment levels that could impact caries experience.

**Table 4.18 Mean DMFT scores by age cohort, education level and SES**

| Covariates | N | Mean + SD | Significance |
|---|---|---|---|
| **Age group** | | | |
| 13-17[a] | 34 | 0.50 + 1.05 | F=10.37 |
| 18-27[b] | 236 | 0.53 + 1.10 | p=0.00* |
| 28-37[c] | 177 | 1.31 + 2.37 | |
| 38-47[d] | 100 | 1.76 + 2.42 | |
| 48-57[e] | 53 | 2.42 + 3.77 | |
| 58-65[f] | 24 | 2.83+ 5.37 | |
| >66[g] | 11 | 3.00 + 2.72 | |
| **Level of education** | | | |
| None | 30 | 1.37 + 2.17 | F=1.42 |
| Koranic | 358 | 1.36 + 2.54 | p=0.21 |
| Primary | 139 | 1.27 + 2.77 | |
| Secondary | 105 | 0.68 + 1.19 | |
| Tertiary | 1 | 1.33 + 2.31 | |
| **SES** | | | |
| Middle | 412 | 1.28 + 2.41 | t=0.75 |
| Low | 223 | 1.13 + 2.42 | p=0.46 |

Post hoc analysis
ab- not significant
ac- not significant
ad- not significant
cd - not significant
ce - not significant
cf - not significant
cg - not significant
de - not significant
df - not significant
dg - not significant
ef - not significant
eg - not significant
fg - not significant

*4.5.3 Association between oral health practices and mean DMFT scores*

**Table 4.19** provides information on the associations between mean DMFT scores and the covariates of oral hygiene status and oral health practices. Oral hygiene status was significantly associated with the women's caries experience using Post hoc analysis with Games-Howell multiple comparisons of means. Women with poor oral hygiene had the highest DMFT scores while those with good oral hygiene had the lowest. The significant difference observed was among the three categories of oral hygiene status (ab, bc and ac). Women who visited the dentist had significantly higher caries experience than those who did not seek dental treatment based on Student's t-test analysis (2.18±3.42 vs. 1.15±2.29 respectively), suggesting that women with symptomatic carious teeth were more likely to seek dental care. The remaining covariates (frequency of sugar consumption between meals, tooth cleaning and fluoride in toothpaste) were not significantly associated with caries experience (p>0.05) **(Table 4.19).**

**Table 4.19 Mean DMFT scores by oral hygiene practices/behaviours**

| Covariates | N | Mean ± SD | Significance |
|---|---|---|---|
| **Oral hygiene status** | | | |
| Good[a] | 16 | 0.13 ± 0.34 | F=7.75 |
| Fair[b] | 195 | 0.76 ± 1.46 | p=0.00* |
| Poor[c] | 424 | 1.48 ± 2.75 | |
| **Frequency of tooth cleaning** | | | |
| I don't brush | 12 | 1.58 ± 2.50 | F=1.05 |
| Once daily | 77 | 1.51 ± 2.59 | p=0.37 |
| Twice a day | 213 | 1.01 ± 1.65 | |
| >Twice a day | 333 | 1.29 ± 2.76 | |
| **Fluoride in toothpaste** | | | |
| Yes | 393 | 1.09 ± 2.07 | t=-1.83 |
| No | 242 | 1.45 ± 2.88 | p=0.07 |
| **Visit to the dentist** | | | |
| Yes | 49 | 2.18 ± 3.42 | t=2.09 |
| No | 586 | 1.15 ± 2.29 | p=0.00* |
| **Frequency of sugar consumption between meals** | | | |
| Always | 61 | 1.70 ± 3.32 | F=1.78 |
| Sometimes | 303 | 1.27 ± 2.47 | p=0.17 |
| Rarely | 271 | 1.07 ± 2.09 | |

Post hoc analysis
ab, ac, bc -significant

*4.5.4 Association between BMI status and mean DMFT scores*

Caries experience varied proportionally to increasing BMI values. Underweight women had the lowest level of caries experience, while overweight/obese women had the highest mean DMFT score. Post hoc analysis with Games-Howell multiple comparisons of means revealed a statistically significant difference between the extremes of BMI status (ab) (F=2.95, p=0.045) **(Table 4.20).**

**Table 4.20 Mean DMFT scores by BMI**

| BMI Categories | N (635) | Mean ± SD | Significance |
|---|---|---|---|
| Underweight[a] | 75 | 0.75 ± 1.97 | F=2.95 |
| Normal[b] | 419 | 1.20 ± 2.32 | p=0.045* |
| Overweight/obese[c] | 140 | 1.57 ± 2.84 | |

Post hoc analysis
ab, bc – not significant

The mean DMFT scores differed significantly between the low and high parity women with normal BMI status using Student's t-test (p=0.00). Similarly, a significant difference was observed between the parity groups for overweight/obese women (p=0.00) **(Table 4.21).** Based on these results, the BMI status is generally associated with caries experience, with the exception of the smaller cohort of underweight women where the association was only approaching significance at p=0.06.

**Table 4.21 Mean DMFT scores by BMI status and parity groups**

| BMI Categories | Low parity | | High parity | | p- value |
|---|---|---|---|---|---|
| | N (354) | Mean ± SD | N (281) | Mean ± SD | |
| Underweight | 51 | 0.43 ± 1.04 | 24 | 1.33 ± 3.09 | 0.08 |
| Normal | 241 | 0.84 ± 1.67 | 179 | 1.69 ± 2.91 | 0.00* |
| Overweight/obese | 62 | 0.87 ± 1.45 | 78 | 2.13 ± 3.50 | 0.00* |

## 4.6 Multivariate analysis of predictors of caries experience

### *4.6.1 Regression analysis between socio-demographic variables, reproductive parameters, oral hygiene status and DMFT scores*

A linear regression (stepwise) was performed to predict the socio-demographic factors (age, socio-economic status and level of education), reproductive parameters (age at first and last birth and parity), BMI status and oral hygiene status that contribute to the caries experience of the women. Model fitting was done and it showed a perfect fit (p=0.00). Women's age and number of children were significantly associated with caries experience (p<0.05 respectively) **(Table 4.22).** Age accounted for 8.5% ($R^2$=0.085, p=0.00) of caries experience while parity contributed 0.8% ($R^2$=0.093, p=0.03).

**Table 4.22 Linear regression of age and parity against DMFT score**

| | Unstandardized Coefficients | | | 95% Confidence Interval for B | |
|---|---|---|---|---|---|
| **Predictors** | B | **Std. Error** | **Sig.** | **Lower Bound** | **Upper Bound** |
| (Constant) | -.66 | .28 | .02 | -1.20 | -.12 |
| Age | .06 | .01 | .00 | .04 | .07 |
| (Constant) | -.66 | .28 | .02 | -1.20 | -.12 |
| Age | .05 | .01 | .00 | .03 | .06 |
| Parity | .09 | .04 | .03 | .01 | .18 |
| **Non- significant variables** | | | | | |
| | B | **t** | **Sig.** | **Partial Correlation** | |
| Level of education | .025 | .600 | .549 | .025 | |
| Age at first child | -.081 | -1.982 | .048 | -.081 | |
| Age at last child | .101 | 1.439 | .151 | .059 | |
| Parity | .111 | 2.251 | .025 | .092 | |
| Oral hygiene status | .067 | 1.629 | .104 | .067 | |
| SES status | .014 | .365 | .716 | .015 | |
| BMI status | .038 | .948 | .343 | .039 | |

*4.6.2 Regression analysis between oral hygiene practices and DMFT scores*

Linear regression was performed to predict the oral hygiene practices/behaviours (frequency of tooth cleaning, use of fluoridated toothpaste, frequency of consumption of sugar between meals and dental visit) that contribute to caries experience in the women. Model fitting was perfect (p=0.00). The use of fluoridated toothpaste, frequency of consumption of sugar between meals and dental visit were significantly associated with caries ($p<0.05$ respectively) **(Table 4.23).** Dental visit contributed 2.5% to the caries experience in the women ($R^2$=0.25, p=0.03).

**Table 4.23 Linear regression of oral hygiene practices/behaviours against DMFT score**

| | Unstandardized Coefficients | | Standardized Coefficients | | 95.0% Confidence Interval for B | |
|---|---|---|---|---|---|---|
| **Predictors** | **B** | **Std. Error** | **Beta** | **Sig.** | **Lower Bound** | **Upper Bound** |
| (Constant) | 3.21 | .85 | | .00 | 1.55 | 4.88 |
| Frequency of tooth cleaning | .04 | .13 | .01 | .76 | -.21 | .28 |
| Fluoride in toothpaste | .44 | .20 | .09 | .03 | .04 | .83 |
| Frequency of sugar consumption between meals | -.31 | .15 | -.08 | .04 | -.61 | -.02 |
| Dental visit | -1.01 | .36 | -.11 | .01 | -1.71 | -.31 |

## 4.7 Relationship between parity and periodontal disease

The periodontal status of the women was assessed using the Community Periodontal Index (CPI). Ten index teeth and six sextants were assessed per participant. The CPI scores range from code 0 through 4 as follows: 0- healthy periodontal status, 1- bleeding on probing, 2- calculus detected on probing, 3- periodontal pockets 4-5 mm and 4- periodontal pockets $\geq$6 mm.

Prevalence of bleeding, calculus and periodontal pockets are presented as the percentage of participants affected. Prevalence of healthy sextants is reported as the percentage of participants with six healthy sextants. The severity of periodontal condition is assessed by the mean number of sextants having code 0, 1 or higher; 2 or higher; 3 or higher and 4.

*4.7.1 Association between age and periodontal condition*

The overall prevalence of periodontal disease in the participants was extremely high (97.5%). For most of the women (59.8%) their periodontal status was characterized by presence of calculus (CPI 2) while 9.4% had periodontal pockets (codes 3 and 4). Of the few participants with healthy periodontal status, 81.3% were in the younger age cohort of 13-27 years. Older women constitute the majority of those with CPI 3, however, there were 4 (1.7%) women aged 18-27 years with periodontal pockets of 4-5 mm (**Table 4.24**). Age has a major influence on the periodontal health due to its generally cumulative expression, thus it is not surprising that the periodontal scores of the women varies with increasing age. This is evident by the fact that none of the participants aged ≥38 years had healthy periodontiums (code 0) (**Table 4.24**). The observed pattern of periodontal disease in the sample population can probably be explained by the age distribution and the poor level of oral health care practices.

**Table 4.24 CPI scores by age group***

| Age group (years) | CPI score | | | | | Total |
|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | |
| 13-17 | 6 (17.6) | 13 (38.2) | 15 (44.1) | 0 (0) | 0 (0) | 34 (100.0) |
| 18-27 | 7 (3.0) | 99 (41.9) | 126 (53.4) | 4 (1.7) | 0 (0) | 236 (100.0) |
| 28-37 | 3 (1.7) | 50 (28.2) | 119 (67.2) | 5 (2.8) | 0 (0) | 177 (100.0) |
| 38-47 | 0 (0) | 11 (11.0) | 75 (75.0) | 14 (14.0) | 0 (0) | 100 (100.0) |
| 48-57 | 0 (0) | 5 (9.4) | 34 (64.2) | 12 (22.6) | 2 (3.8) | 53 (100.0) |
| 58-65 | 0 (0) | 1 (4.2) | 8 (33.3) | 15 (62.5) | 0 (0) | 24 (100.0) |
| ≥ 66 | 0 (0) | 0 (0) | 3 (27.3) | 6 (54.5) | 2 (18.2) | 11 (100.0) |
| **Total** | **16 (2.5)** | **179 (28.2)** | **380 (59.8)** | **56 (8.8)** | **4 (0.6)** | **635 (100.0)** |

*Reported as number and percentage

The overall severity of the periodontal conditions is indicated by the mean sextant scores for codes 0 through 4 that decrease consistently with increasing age (**Table 4.25**). Participants aged 13-17 years experienced better periodontal conditions, while those aged ≥66 had the least healthy periodontiums (4.50±0.93 vs. 3.18±0.60 respectively). The presence of calculus was more frequent in participants aged 38-47, but less common in women aged 13-17 years (1.29±0.80 vs. 0.59±0.78 respectively).

The worst periodontal attachment losses (codes 3 and 4) were observed in the older age cohorts. Women aged $\geq$66 had the most periodontal attachment loss of 4-5 mm while those aged 48-57 years experienced more losses of $\geq$6 mm than any other cohort (0.91$\pm$0.30 and 0.38$\pm$0.19 respectively). Post hoc analysis with Games-Howell multiple comparisons of means shows a statistically significant difference in the means of the sextant scores by age cohort (p<0.05 respectively) (**Table 4.25**).

**Table 4.25 Mean number of sextants with CPI scores by age group***

| Age group (years) (N) | Mean CPI =0 | Mean CPI =1 | Mean CPI =2 | Mean CPI =3 | Mean CPI =4 |
|---|---|---|---|---|---|
| 13-17[a] (34) | 4.50 $\pm$ 0.93 | 0.91 $\pm$ 0.93 | 0.59 $\pm$ 0.78 | 0.00 $\pm$ 0.00 | 0.00 $\pm$ 0.00 |
| 18-27[b] (236) | 3.91 $\pm$ 0.87 | 1.24 $\pm$ 0.96 | 0.83 $\pm$ 0.87 | 0.02 $\pm$ 0.13 | 0.00 $\pm$ 0.00 |
| 28-37[c] (177) | 3.71 $\pm$ 0.81 | 1.31 $\pm$ 0.96 | 0.94 $\pm$ 0.78 | 0.03 $\pm$ 0.18 | 0.01 $\pm$ 0.08 |
| 38-47[d] (100) | 3.53 $\pm$ 0.80 | 1.05 $\pm$ 1.00 | 1.29 $\pm$ 0.80 | 0.15 $\pm$ 0.36 | 0.01 $\pm$ 0.10 |
| 48-57[e] (53) | 3.40 $\pm$ 0.79 | 0.96 $\pm$ 0.85 | 1.23 $\pm$ 0.82 | 0.36 $\pm$ 0.59 | 0.38 $\pm$ 0.19 |
| 58-65[f] (24) | 3.33 $\pm$ 0.56 | 0.75 $\pm$ 0.79 | 1.21 $\pm$ 0.59 | 0.75 $\pm$ 0.44 | 0.00 $\pm$ 0.00 |
| $\geq$ 66[g] (11) | 3.18 $\pm$ 0.60 | 0.82 $\pm$ 0.75 | 0.91 $\pm$ 0.54 | 0.91 $\pm$ 0.30 | 0.18 $\pm$ 0.40 |
| **Total** | **3.75 $\pm$ 0.87** | **1.16 $\pm$ 0.96** | **0.96 $\pm$ 0.83** | **0.11 $\pm$ 0.33** | **0.01 $\pm$ 0.10** |
| **F** | 10.87 | 2.99 | 6.22 | 53.97 | 7.51 |
| **p-value** | 0.00* | 0.00* | 0.00* | 0.00* | 0.00* |

*The mean number of sextants is calculated as the mean number of segments with a particular CPI score

Post hoc analysis shows p<0.05 for the followings

CPI 0 – ab, ac, ad, ae, af, ag, bd, be, bf, bg

CPI 1 -cf

CPI 2 –ad, ae, af, bd, be, cd

CPI 3 – ad, ae, af, ag, bd, be, bf, bg, cd, ce, cf, cg, df, dg, ef, eg

### *4.7.2 Association between parity and periodontal condition*

Generally, the periodontal conditions of the participants varied with increasing parity. Both high and low parity women experienced bleeding on probing (code 1). However, low parity women experienced healthier periodontium (codes 0) than high parity women who had more calculus (codes 2). About 12.8% and 48.9% of nulliparous women experienced healthy periodontium and bleeding on probing respectively while 31.9% and 6.4% of them had calculus and periodontal pockets 4-5 mm respectively. However, among women with five children, 1.2% and 24.4% experienced codes 0 and 1 respectively while 62.2% and 12.2% had codes 2 and 3 respectively. The majority (87.5%) of women with low parity ($\leq$4) had healthy periodontal statuses. Of these six were nulliparous and five had only one child. However, a woman with seven children also had a code 0 score. The majority of women with nine or more children (75.0%) had calculus, and 20.9% of participants with six children had periodontal attachment loss of 4-5 mm (code 3) (**Table 4.26**). Only a few women (0.6%) experienced periodontal pockets of $\geq$6 mm (code 4). The data suggest that parity influences periodontal status in the women, yet there are confounders that contribute to the observed variation. Therefore, further analysis of the data was carried out.

**Table 4.26 CPI scores by parity***

| Parity | CPI Score | | | | | Total |
|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | |
| 0 | 6 (12.8) | 23 (48.9) | 15 (31.9) | 3 (6.4) | 0 (0) | 47 (100.0) |
| 1 | 5 (5.6) | 41 (46.1) | 42 (47.2) | 1 (1.1) | 0 (0) | 89 (100.0) |
| 2 | 0 (0) | 19 (27.5) | 48 (69.6) | 2 (2.9) | 0 (0) | 69 (100.0) |
| 3 | 1 (1.4) | 19 (25.7) | 49 (66.2) | 3 (4.1) | 2 (2.7) | 74 (100.0) |
| 4 | 2 (2.7) | 23 (30.7) | 44 (58.7) | 6 (8.0) | 0 (0) | 75 (100.0) |
| 5 | 1 (1.2) | 20 (24.4) | 51 (62.2) | 10 (12.2) | 0 (0) | 82 (100.0) |
| 6 | 0 (0) | 9 (20.9) | 24 (55.8) | 9 (20.9) | 1 (2.3) | 43 (100.0) |
| 7 | 1 (1.9) | 11 (20.4) | 34 (63.0) | 7 (13.0) | 1 (1.9) | 54 (100.0) |
| 8 | 0 (0) | 7 (18.4) | 25 (65.8) | 6 (15.8) | 0 (0) | 38 (100.0) |
| $\geq$9 | 0 (0) | 7 (10.9) | 48 (75.0) | 9 (14.1) | 0 (0) | 64 (100.0) |
| **Total** | **16 (2.5)** | **179 (28.2)** | **380 (59.8)** | **56 (8.8)** | **4 (0.6)** | **635 (100.0)** |

* presented as number and percentage

Two trends are observed for the relationship between parity and the severity of periodontal conditions in the participants. The severity of periodontal disease was typically less in women of low parity, while the reverse was the case for high parity women. Nulliparous women had the highest mean sextant score (4.21$\pm$0.99) signifying healthy periodontium followed by women with only one child (4.03$\pm$0.92); those with nine or more children had the lowest score (3.52$\pm$0.71) among the code 0 group. Women with nine or more children experienced more calculus (1.27$\pm$0.82) than other women. Interestingly, the score of periodontal pockets of 4-5 mm (code 3) was greatest in women with six children (0.26$\pm$0.44), followed by those with eight children (0.21$\pm$0.41) (**Table 4.27)**. No obvious trend is observed between parity and severity of pockets $\geq$6 mm (code 4).

Severity of the periodontal conditions was found to differ significantly by parity for codes 0, 2 and 3 (p<0.05) using Post hoc analysis with Games-Howell multiple comparisons of means (**Table 4.27**).

**Table 4.27 Mean number of sextants with CPI scores by parity**

| Parity (N) | Mean CPI =0 | Mean CPI =1 | Mean CPI =2 | Mean CPI =3 | Mean CPI =4 |
|---|---|---|---|---|---|
| 0[a] (47) | 4.21 ± 0.99 | 1.26 ± 0.92 | 0.45 ± 0.65 | 0.09 ± 0.28 | 0.00 ± 0.00 |
| 1[b] (89) | 4.03 ± 0.92 | 1.18 ± 1.03 | 0.80 ± 0.91 | 0.01 ± 0.11 | 0.00 ± 0.00 |
| 2[c] (69) | 3.65 ± 0.76 | 1.26 ± 0.89 | 1.03 ± 0.87 | 0.03 ± 0.17 | 0.00 ± 0.00 |
| 3[d] (74) | 3.72 ± 0.91 | 1.12 ± 1.03 | 1.08 ± 0.89 | 0.05 ± 0.23 | 0.03 ± 0.16 |
| 4[e] (75) | 3.72 ± 0.91 | 1.26 ± 1.00 | 0.92 ± 0.87 | 0.11 ± 0.31 | 0.00 ± 0.00 |
| 5[f] (82) | 3.57 ± 0.80 | 1.13 ± 0.87 | 1.13 ± 0.75 | 0.17 ± 0.41 | 0.02 ± 0.16 |
| 6[g] (43) | 3.67 ± 0.68 | 1.12 ± 0.93 | 0.91 ± 0.69 | 0.26 ± 0.44 | 0.02 ± 0.15 |
| 7[h] (54) | 3.69 ± 0.93 | 1.20 ± 1.03 | 0.94 ± 0.71 | 0.15 ± 0.41 | 0.02 ± 0.14 |
| 8[i] (38) | 3.76 ± 0.54 | 1.00 ± 0.81 | 1.05 ± 0.77 | 0.21 ± 0.41 | 0.00 ± 0.00 |
| ≥9[j] (64) | 3.52 ± 0.71 | 1.01 ± 0.97 | 1.27 ± 0.82 | 0.19 ± 0.43 | 0.00 ± 0.00 |
| **Total** | **3.75 ± 0.87** | **1.16 ± 0.96** | **0.96 ± 0.83** | **0.11 ± 0.33** | **0.01 ± 0.10** |
| **F** | 2.49 | 1.08 | 2.79 | 3.37 | 0.58 |
| **p-value** | 0.00* | 0.37 | 0.00* | 0.00* | 0.90 |

*Post hoc analysis could not be performed because at least one group had fewer than two cases

The mean CPI scores of the women varied with increasing parity, as seen in **Table 4.28.** The lowest mean score (1.32) was observed in nulliparous women and the highest (2.05) was noted for participants with six children. Correlation analysis with a Spearman's Rho test between parity and mean CPI score was statistically significant (ρ=0.89, p=0.00). This indicates that parity had a positive relationship to mean CPI score **(Table 4.28).**

**Table 4.28 Correlation analysis between parity and mean CPI scores**

| Parity | N | Mean CPI score** | |
|---|---|---|---|
| 0 | 47 | 1.32 | ρ=0.89 |
| 1 | 89 | 1.44 | p=0.00* |
| 2 | 69 | 1.75 | |
| 3 | 74 | 1.81 | |
| 4 | 75 | 1.72 | |
| 5 | 82 | 1.85 | |
| 6 | 43 | 2.05 | |
| 7 | 54 | 1.93 | |
| 8 | 38 | 1.97 | |
| ≥9 | 64 | 2.03 | |

** The value used in the correlation analysis.

**4.8 Association between socio-demographic variables and periodontal conditions**

Individuals of lower SES typically experience poorer oral health than individuals of middle and high SES. However, the reverse was the case in this sample population as more middle SES women had worse periodontal scores. As presented above, the middle SES group was weighted toward older women, so it was expected that they would have higher CPI scores (over 70% were code 2 and above). The periodontal scores of the two SES groups were found to differ significantly using the Chi-square test (Likelihood ratio $\chi^2$=9.77, p=0.045) (**Table 4.29**).

**Table 4.29 CPI score by socio-economic status**

| SES | CPI Score | | | | | Total |
|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | |
| Middle | 6 (1.5) | 106 (25.7) | 260 (63.1) | 37 (9.0) | 3 (0.7) | 412 (100.0) |
| Low | 10 (4.5) | 73 (32.7) | 120 (53.8) | 19 (8.5) | 1 (0.4) | 223 (100.0) |
| **Total** | **16 (2.5)** | **179 (28.2)** | **380 (59.8)** | **56 (8.8)** | **4 (0.6)** | **635 (100.0)** |

**Table 4.30** provides information on the level of educational attainment and CPI scores. An obvious pattern can be observed in the periodontal health relative to educational status. More than half of the women with no form of education, Koranic education, or primary schooling had CPI scores of 2 and higher. Although the number of women with tertiary education was very small, all had a CPI score of 1. Similarly,

about half (47.6%) of the participants with secondary education experienced bleeding on slight probing (code 1) (**Table 4.30**). The results suggest that a woman's level of education influenced her periodontal health.

**Table 4.30 CPI score by educational status**

| Educational Status | CPI Score | | | | | Total |
|---|---|---|---|---|---|---|
| | **0** | **1** | **2** | **3** | **4** | |
| None | 1 (3.3) | 7 (23.3) | 16 (53.3) | 6 (20.0) | 0 (0) | 30 (100.0) |
| Koranic school | 5 (1.4) | 64 (17.9) | 243 (67.9) | 42 (11.7) | 4 (1.1) | 358 (100.0) |
| Primary school | 4 (2.9) | 55 (39.6) | 75 (54.0) | 5 (3.6) | 0 (0) | 139 (100.0) |
| Secondary school | 6 (5.7) | 50 (47.6) | 46 (43.8) | 3 (2.9) | 0 (0) | 105 (100.0) |
| Tertiary | 0 (0) | 3 (100.0) | 0 (0) | 0 (0) | 0 (0) | 3 (100.0) |
| **Total** | **16 (2.5)** | **179 (28.2)** | **380 (59.8)** | **56 (8.8)** | **4 (0.6)** | **635 (100.0)** |

### 4.9 Association between oral health practices and CPI scores

Periodontal health status of the participants varied by the frequency of tooth cleaning. This was more pronounced between those women who reported that they do not clean their teeth at all and those who clean more than twice daily. The majority of women (11 out of 12) who do not clean their teeth at all (over 90%) had CPI scores of 2 and higher. This was followed by those who clean more than twice daily (217 out of 333, 65.2%) for code 2 (**Table 4.31**). Not cleaning the teeth results in plaque accumulation that is associated with periodontitis. It is likely that the majority of the participants who claimed that they clean their teeth more than twice daily have not been doing so effectively to remove plaque.

**Table 4.31 CPI scores by frequency of tooth cleaning**

| Frequency of tooth cleaning | CPI score | | | | | Total |
|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | |
| I don't clean | 0 (0) | 1 (8.3) | 8 (66.7) | 2 (16.7) | 1 (8.3) | 12 (100.0) |
| Once daily | 2 (2.6) | 24 (31.2) | 41 (53.2) | 9 (11.7) | 1 (1.3) | 77 (100.0) |
| Twice daily | 7 (3.3) | 80 (37.6) | 114 (53.5) | 12 (5.6) | 0 (0) | 213 (100.0) |
| > Twice daily | 7 (2.1) | 74 (22.2) | 217 (65.2) | 33 (9.9) | 2 (0.6) | 333 (100.0) |
| **Total** | **16 (2.5)** | **179 (28.2)** | **380 (59.8)** | **56 (8.8)** | **4 (0.6)** | **635 (100.0)** |

### 4.10 Association between BMI status and CPI scores

There is no obvious pattern between the BMI status and the CPI score of the participants. The majority of the women displayed calculus (code 2). However, there were more overweight/obese participants (12.9%) with periodontal attachment loss of 4-5 mm (code 3) than those who were underweight and normal (8.0% and 7.6% respectively) (**Table 4.32**).

**Table 4.32 CPI scores by BMI status**

| Nutritional status | CPI Score | | | | | Total |
|---|---|---|---|---|---|---|
| | 0 | 1 | 2 | 3 | 4 | |
| Underweight | 3 (4.0) | 23 (30.7) | 43 (57.3) | 6 (8.0) | 0 (0) | 75 (100.0) |
| Normal | 13 (3.1) | 119 (28.3) | 253 (60.2) | 32 (7.6) | 3 (0.7) | 420 (100.0) |
| Overweight/obese | 0 (0) | 37 (26.4) | 84 (60.0) | 18 (12.9) | 1 (0.7) | 140 (100.0) |
| **Total** | **16 (2.5)** | **179 (28.2)** | **380 (59.8)** | **56 (8.8)** | **4 (0.6)** | **635 (100.0)** |

### 4.11 Regression analysis between oral hygiene practices, socio-demographic factors, BMI status, parity and CPI scores

A linear regression (stepwise) was conducted to predict the socio-demographic factors (age, educational status, socio-economic status), oral hygiene practices, BMI status, and parity that contribute to periodontal experience in the participants. Model fitting was done and it showed a perfect fit (p=0.00). Age, educational status and frequency of tooth cleaning were significantly associated with periodontal experience in the women ($p<0.05$ respectively) (**Table 4.33**). Age accounted for 23.6% ($R^2$=0.236, p=0.00) of periodontal experience observed in the participants while educational status and frequency of tooth cleaning contributed 1.6% ($R^2$=0.252, p=0.00) and 1.2% ($R^2$=0.264, p=0.00) respectively. Notably, parity did not contribute to the prediction of CPI score.

**Table 4.33 Linear regression of socio-demographic factors, BMI status, parity and oral hygiene practices against CPI scores**

| Predictors | Unstandardized Coefficients | | Standardized Coefficients | Sig. | 95.0% Confidence Interval for B | |
|---|---|---|---|---|---|---|
| | B | Std. Error | Beta | | Lower Bound | Upper Bound |
| (Constant) | .951 | .063 | | .000 | .827 | 1.074 |
| Age | .025 | .002 | .485 | .000 | .022 | .029 |
| (Constant) | 1.306 | .114 | | .000 | 1.081 | 1.531 |
| Age | .023 | .002 | .434 | .000 | .019 | .027 |
| Level of education | -.107 | .029 | -.137 | .000 | -.163 | -.050 |
| (Constant) | 1.058 | .138 | | .000 | .787 | 1.329 |
| Age | .023 | .002 | .449 | .000 | .020 | .027 |
| Level of education | -.107 | .029 | -.137 | .000 | -.163 | -.051 |
| Frequency of tooth cleaning | .095 | .030 | .109 | .002 | .036 | .153 |
| **Non- significant variables** | | | | | | |
| | **B** | | **T** | **Sig** | **Partial Correlation** | |
| Parity | .000 | | -.008 | .994 | .000 | |
| BMI status | -.008 | | -.229 | .819 | -.009 | |

## 4.12 Relationship between parity and tooth loss

### 4.12.1 Socio-demographic characteristics of sub study participants

Old age is strongly associated with higher prevalence of tooth loss in all population due to the accumulated wear and damage to the dentition. Thus women aged $\geq$66 were excluded from the analysis because their inclusion was likely to affect the outcome of the results and obscure the effect of parity on tooth loss. Twenty-three older women were removed from the analysis, resulting in a subsample of 612 participants. Their ages ranged from 13 to 65 years with a mean age of 31.06$\pm$11.42 years.

The socio-demographic characteristics, socio-economic status, reproductive parameters, BMI status and oral hygiene practices of the sub sample did not differ from those of the total sample population. The majority (66.5%) of the participants were between 18 to 37 years while the youngest and oldest age cohorts constituted 5.6% and 3.1% respectively. Generally, the level of education was low with 4.7% being illiterate. About 22% attended primary school while only 0.6% had tertiary education. The majority (55.2%) of the participants had the Koranic form of education. Approximately 65% of the women were of middle socio-economic status and the remaining (35%) of low socio-economic status. There were no women of high socio-economic status **(Table 4.34)**.

The socio-economic status of the sub study participants varied by age, with the majority (55.9%) of the women aged 13-17 years of low socio-economic status (**Table 4.35**).

**Table 4.34 Socio-demographic distribution of sub study participants**

| **Age (years)** | **N (%)** |
|---|---|
| 13-17 | 34 (5.6%) |
| 18-27 | 234 (38.2%) |
| 28-37 | 173 (28.3%) |
| 38-47 | 99 (16.2%) |
| 48-57 | 52 (8.5%) |
| 58-65 | 20 (3.1%) |
| **Total** | **612 (100.0%)** |
| **Level of education** | |
| None | 29 (4.7%) |
| Koranic | 338 (55.2%) |
| Primary school (partial or completed) | 137 (22.4%) |
| Secondary school (partial or completed) | 105 (17.2%) |
| Tertiary (partial or completed) | 3 (0.6%) |
| **Socio-economic status** | |
| High (Class I) | 0 (0.0%) |
| Middle (Class II) | 396 (64.7%) |
| Low (Class III) | 216 (35.3%) |

**Table 4.35 Socio-economic status of sub study participants by age**

| Age group (years) | Socio-economic status | | Total |
|---|---|---|---|
| | Middle | Low | |
| 13-17 | 15 (44.1%) | 19 (55.9%) | 34 (100.0%) |
| 18-27 | 136 (58.1%) | 98 (41.9%) | 234 (100.0%) |
| 28-37 | 118 (68.2%) | 55 (31.8%) | 173 (100.0%) |
| 38-47 | 75 (75.8%) | 24 (24.2%) | 99 (100.0%) |
| 48-57 | 39 (75.0%) | 13 (25.0%) | 52 (100.0%) |
| 58-65 | 13 (65.0%) | 7 (35.0%) | 20 (100.0%) |
| **Total** | **396 (64.7%)** | **216 (35.3%)** | **612 (100.0%)** |

### 4.12.2 Reproductive parameters of sub study participants

Parity varied proportionally with increasing age among the women. The majority (86.7%) of the nulliparous women were aged 13-27 while the remaining childless women belonged to the age cohorts 28-37 (8.9%) and 48-65 (4.4%) respectively. The highest parity in the sample was 17, which was noted in a woman aged 58-65. There was an increasing proportion of women with five or more children between 28 and 65 years. However, there was a reduction in the proportion of women 35-65 years with less than five children or greater than ten children (**Table 4.36**).

Generally, there were more women in the low parity group ($\leq$4) than the high parity cohort ($\geq$5) (55.9% vs. 44.1% respectively). The overall mean parity was 4.33$\pm$3.04 children per woman with a range of 0-17. The mean parity was lowest (0.68$\pm$0.91) in women aged 13-17 and highest in those aged 58-65 (7.60$\pm$3.89) (**Table 4.37**).

The reproductive pattern of the women was characterized by early age at first birth. The majority (72.2%) of the women had their first child before the age of 19 years. Fifty percent of women aged 13-17 had given birth before the age of 18 years with two of the participants having had 3 and 4 children respectively. The age at last birth provides little information because many of the participants are still having children (**Table 4.38**).

Other reproductive parameters assessed included interbirth intervals and duration of breastfeeding. The mean interbirth interval was 24.11$\pm$8.52 months with a range of 1 to 9 years while the mean duration of breastfeeding was 19.78$\pm$2.77 months **(Table 4.37**).

**Table 4.36 Parity by age cohort of sub study participants**

| Age (years) | Parity | | | | | | | | | | | | | | | | | Mean + SD | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **0** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **13** | **14** | **15** | **17** | | |
| 13-17 | 17 | 14 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.68 + 0.91 | **34** |
| 18-27 | 22 | 65 | 45 | 47 | 29 | 20 | 3 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2.35 + 1.59 | **234** |
| 28-37 | 4 | 9 | 12 | 12 | 28 | 34 | 19 | 21 | 18 | 9 | 5 | 1 | 1 | 0 | 0 | 0 | 0 | 5.26 + 2.45 | **173** |
| 38-47 | 0 | 0 | 6 | 5 | 12 | 11 | 10 | 19 | 11 | 16 | 4 | 1 | 2 | 1 | 0 | 1 | 0 | 6.65 + 2.59 | **99** |
| 48-57 | 1 | 1 | 1 | 4 | 3 | 9 | 5 | 7 | 5 | 7 | 4 | 1 | 2 | 2 | 0 | 0 | 0 | 6.83 + 2.96 | **52** |
| 58-65 | 1 | 0 | 0 | 0 | 1 | 5 | 3 | 2 | 1 | 1 | 2 | 1 | 1 | 0 | 1 | 0 | 1 | 7.60 + 3.89 | **20** |
| **Total** | **45** | **89** | **65** | **69** | **74** | **79** | **40** | **52** | **35** | **33** | **15** | **4** | **6** | **3** | **1** | **1** | **1** | **4.33 + 3.04** | **612** |

**Table 4.37 Descriptive statistics: reproductive parameters**

| Reproductive parameters | N | Mean $\pm$ SD | Range |
|---|---|---|---|
| Parity | 612 | 4.33 $\pm$ 3.04 | 0-17 |
| Age at first birth (years) | 576 | 17.59 $\pm$ 3.45 | 11-40 |
| Age at last birth (years) | 575 | 27.73 $\pm$ 7.88 | 13-50 |
| Birth intervals (months) | 478 | 24.11 $\pm$ 8.52 | 12-108 |
| Duration of breastfeeding (months) | 548 | 19.78 $\pm$ 2.77 | 12-60 |

**Table 4.38 Reproductive parameters of sub study participants**

| Reproductive parameters | N (%) |
|---|---|
| **Age at first birth (years)** | |
| $\leq$ 18 | 416 (72.2%) |
| 19-24 | 132 (22.9%) |
| 25-29 | 15 (2.6%) |
| $\geq$ 30 | 13 (2.3%) |
| **Age at last birth (years)** | |
| $\leq$ 24 | 227 (39.4%) |
| 25-29 | 117 (20.3%) |
| 30-34 | 97 (16.8%) |
| $\geq$ 35 | 135 (23.4%) |
| **Parity group** | |
| Low parity ($\leq$ 4 children) | 342 (55.9%) |
| High parity ($\geq$ 5 children) | 270 (44.1%) |

### 4.12.3 BMI status of sub study

The majority (66.8%) of the participants were of normal BMI status while 21.4% were overweight/obese. The BMI status of the women varied proportionally with increasing age, with 20.6% underweight women aged 13-17 years while 38.5% overweight/obese women were aged 48-57 years **(Table 4.39)**.

**Table 4.39 BMI status by age**

| Age group (years) | BMI Categories | | | Total |
|---|---|---|---|---|
| | Underweight N(%) | Normal N(%) | Overweight/ Obese N(%) | |
| 13-17 | 7(20.6%) | 25(73.5%) | 2(5.9%) | 34(100.0%) |
| 18-27 | 36(15.4%) | 169(72.2%) | 29(12.4%) | 234(100.0%) |
| 28-37 | 10(5.8%) | 115(66.5%) | 48(27.7%) | 173(100.0%) |
| 38-47 | 14(14.1%) | 60(60.6%) | 25(25.3%) | 99(100.0%) |
| 48-57 | 3(5.8%) | 29(55.8%) | 20(38.5%) | 52(100.0%) |
| 58-65 | 2(10.0%) | 11(55.0%) | 7(35.0%) | 20(100.0%) |
| **Total** | **72(11.8%)** | **409(66.8%)** | **131(21.4%)** | **612(100.0%)** |

### 4.12.4 Oral health practices of sub study participants

The oral hygiene status of the participants was largely poor. Four hundred and three (65.8%) had poor, 31.5% had fair and only 2.6% had good oral hygiene. There was variation in the oral hygiene practices of the women. Approximately 53% of the women responded that they clean their teeth more than twice a day, while 1.6% reported that they did not clean their teeth. The tools for cleaning the teeth differed greatly among the participants. The majority (65.5%) used toothbrush with fluoridated toothpaste (61.9%). About 8% used chewing stick or hand and water (12.7%). Other cleaning tools included charcoal and soap (8.7%) **(Table 4.40).**

**Table 4.40 Tooth cleaning tools and pattern of sub study participants**

| Variables | Number (N=612) |
|---|---|
| **Oral hygiene status** | |
| Good | 16 (2.6%) |
| Fair | 193 (31.5%) |
| Poor | 403 (65.8%) |
| **Tooth cleaning tools** | |
| Toothbrush and toothpaste | 401 (65.5%) |
| Chewing stick | 48 (7.8%) |
| Hand and water | 78 (12.7%) |
| Hand and salt | 26 (4.2%) |
| Cotton wool and salt | 1 (0.2%) |
| Others | 53 (8.7%) |
| **Frequency of tooth cleaning** | |
| I don't brush | 10 (1.6%) |
| Once daily | 73 (11.9%) |
| Twice a day | 208 (34.0%) |
| >Twice a day | 321 (52.5%) |
| **Fluoride in toothpaste** | |
| Yes | 379 (61.9%) |
| No | 233 (38.1%) |
| **Dental visit** | |
| Yes | 45 (7.4%) |
| No | 567 (92.6%) |

*Some participants did not respond to the questions

### 4.13 Relationship between reproductive parameters and mean tooth loss

Tooth loss experience in the participants was low with an overall prevalence of 14.1%. Tooth loss (presence/absence) in the women differs by parity with more tooth loss experienced by higher parity women. Women with only one child experienced the lowest tooth loss, while those with ≥9 children had the highest prevalence of tooth loss (1.1% vs. 34.4% respectively). There was no discernable pattern between tooth loss and parity among 0-4 children. However, at parity 5 and above, tooth loss shows a trend of increase with increasing parity (**Table 4.41**). These results suggest that tooth loss is likely influenced by parity. Therefore further analysis was conducted to assess the effect of parity and other confounding variables on tooth loss.

**Table 4.41 Frequency of tooth loss by parity and parity groups**

| Parity | N | Tooth loss absent N (%) | Tooth loss present N (%) |
|---|---|---|---|
| 0 | 45 | 42 (93.3%) | 3 (6.7%) |
| 1 | 89 | 88 (98.9%) | 1 (1.1%) |
| 2 | 65 | 59 (90.8%) | 6 (9.2%) |
| 3 | 69 | 64 (92.8%) | 5 (7.2%) |
| 4 | 74 | 66 (89.2%) | 8 (10.8%) |
| 5 | 79 | 65 (82.3%) | 14 (17.7%) |
| 6 | 40 | 31 (77.5%) | 9 (22.5%) |
| 7 | 52 | 42 (80.8%) | 10 (19.2%) |
| 8 | 35 | 27 (77.1%) | 8 (22.9%) |
| ≥9 | 64 | 42 (65.6%) | 22 (34.4%) |
| **Parity group** | | | |
| Low ≤4 | 342 | 319 (93.3%) | 23 (6.7%) |
| High ≥5 | 270 | 207 (76.7%) | 63 (23.3%) |
| **Total** | **612** | **526 (85.9%)** | **86 (14.1%)** |

There was wide variation in the number of teeth lost per individual. The overall mean tooth loss among the women was generally low (0.54±2.15) with a range of 1-21 teeth involved.

**Table 4.42** provides information on the association between reproductive parameters (parity group, age at first birth, duration of reproduction and interbirth interval) and mean tooth loss. The parity group and duration of reproduction were significantly associated with the mean number of teeth lost ($p<0.05$ respectively). Between the two parity groups, high parity women experienced significantly greater tooth loss than low parity women. The difference was statistically significant using Student's t-test analysis ($p=0.00$). The mean tooth loss varied proportionally with increasing duration of reproduction. Women with a duration of ≥18 reproductive years experienced greater tooth loss, while those with a reproductive span of ≤5 years had the lowest (1.36±3.80 vs. 0.07±0.41 respectively). Post hoc testing with Games-Howell multiple comparisons of means showed a statistically significant difference between the extremes of reproductive duration.

Although women with delayed age at first birth experienced more tooth loss than those with earlier age at first birth, the difference was not statistically significant (post hoc analysis with Games-Howell multiple comparisons of means, p=0.63). Interestingly, women with the shortest interbirth interval (<3 years) had greater mean tooth loss (0.58±2.34) than those with longer intervals (0.36±1.05 and 0.40±1.12), yet the difference was not statistically significant (p=0.61) (**Table 4.42**). These results show that relationships exist between the different reproductive parameters and tooth loss. The associations are stronger for parity and duration of reproduction.

**Table 4.42 Mean tooth loss by reproductive parameters**

| Covariates | N | Number of teeth lost Mean ± SD | Significance |
|---|---|---|---|
| **Parity group** | | | |
| Low parity ≤4 | 342 | 0.09 ± 0.38 | t =5.93 |
| High parity ≥5 | 270 | 1.10 ± 3.12 | p= 0.00* |
| **Age at first birth (years)** | | | |
| ≤ 18 | 416 | 0.53 ± 2.16 | F=0.64 |
| 19-24 | 132 | 0.62 ± 2.44 | p=0.63 |
| 25-29 | 15 | 1.00 ± 2.10 | |
| ≥ 30 | 13 | 0.69 ± 1.70 | |
| **Duration of reproduction (years)** | | | |
| ≤5[a] | 213 | 0.07± 0.41 | F=9.65 |
| 6-11[b] | 157 | 0.39± 1.85 | p=0.00* |
| 12-17[c] | 143 | 0.82± 2.24 | |
| ≥ 18[d] | 99 | 1.36± 3.80 | |
| **Interbirth interval (years)** | | | |
| <3 | 491 | 0.58± 2.34 | F=0.50 |
| 3-5 | 106 | 0.36± 1.05 | p=0.61 |
| ≥6 | 15 | 0.40± 1.12 | |
| **Overall mean** | 612 | 0.54 ± 2.15 | |

Post hoc analysis
Significant –ac, ad

There was an obvious trend in the mean tooth loss by parity groups when age is also considered. This trend was more distinct in high parity women as evident by the increase in tooth loss with increasing age. However, the trend was less consistent in the low parity cohort, and may be due to smaller age cohorts. Women of high parity experienced greater tooth loss in all age cohorts than those of low parity. As expected, a huge difference was observed in the oldest age group (58-65 years), where high parity women experienced greater tooth loss than both their younger parity group members and their low parity age mates. The difference in the mean tooth loss was found to be not statistically significant using Student’s t-test analysis and this applies to the other age groups ($p>0.05$). The non-significant difference observed can be attributed to the wide standard deviations (**Table 4.43**).

**Table 4.43 Mean tooth loss by parity group**

| **Age group (yrs)** | **Low parity ≤4** | | **High parity ≥5** | | **p-value** |
|---|---|---|---|---|---|
| | **N (342)** | **Mean ± SD** | **N (270)** | **Mean ± SD** | |
| 13-17 | 34 | 0.03 ± 0.17 | 0 | - | |
| 18-27 | 208 | 0.06 ± 0.27 | 26 | 0.08 ± 0.27 | 0.72 |
| 28-37 | 65 | 0.14 ± 0.39 | 108 | 0.20 ± 0.73 | 0.54 |
| 38-47 | 23 | 0.09 ± 0.42 | 76 | 1.34 ± 3.18 | 0.06 |
| 48-57 | 10 | 0.60 ± 1.35 | 42 | 1.69 ± 3.84 | 0.19 |
| 58-65 | 2 | 0.50 ± 0.71 | 18 | 5.61 ± 6.39 | 0.28 |

The lowest mean tooth loss was observed in women with only one child while the highest was noted in those with ≥9 (0.01 vs. 1.84) **(Table 4.44)**. There was no discernable pattern between mean tooth loss and parity among the low parity (≤4) levels. At parity 5 and above, tooth loss was proportional to increasing parity (although a reduction was noted at parity 7). Women with five children experienced 3 times more tooth loss than those with four children (0.56 vs. 0.18). Correlation analysis (Spearman Rho) showed that mean tooth loss varied significantly with increasing parity in Hausa women ($\rho=0.95$, $p=0.00$) (**Table 4.44).**

**Table 4.44 Correlation analysis between parity and mean tooth loss**

| Parity | N | Mean tooth loss** | Significance |
|---|---|---|---|
| 0 | 45 | 0.09 | ρ=0.95 |
| 1 | 89 | 0.01 | p=0.00* |
| 2 | 65 | 0.12 | |
| 3 | 69 | 0.09 | |
| 4 | 74 | 0.18 | |
| 5 | 79 | 0.56 | |
| 6 | 40 | 1.18 | |
| 7 | 52 | 0.81 | |
| 8 | 35 | 1.34 | |
| $\geq$ 9 | 64 | 1.84 | |

** The value used in the correlation analysis.

**4.14 Association between socio-demographic characteristics and mean tooth loss**

**Table 4.45** provides information on the association between the socio-demographic variables (age, SES and level of education) and mean tooth loss. Age was significantly associated with mean tooth loss using post hoc analysis with Games-Howell multiple comparisons of means. Women aged 13-17 years experienced less tooth loss compared to women in other age cohorts, while those aged 58-65 had greater tooth loss than other women. The significant difference observed was among ae, bd, be, bf, ce, cf, df, ef (F=30.83, p=0.00).

Similar trends of tooth loss were observed in relation to the level of education and SES. Women with no form of education lost more teeth than those with other forms of education (1.21$\pm$3.79). The only woman with post secondary school education did not experience tooth loss. Participants from middle SES had greater tooth loss than those from low SES. However, there was no statistically significant association between level of education, SES and tooth loss using post hoc analysis with Games-Howell multiple comparisons of means and Student's t-test analysis respectively **(Table 4.45).**

**Table 4.45 Mean tooth loss by age cohort, education level and SES**

| Covariates | N | Number of teeth lost Mean ± SD | Significance |
|---|---|---|---|
| **Age group (years)** | | | |
| 13-17[a] | 34 | 0.03 ± 0.17 | F=30.83 |
| 18-27[b] | 234 | 0.06 ± 0.27 | p=0.00* |
| 28-37[c] | 173 | 0.18 ± 0.63 | |
| 38-47[d] | 99 | 1.05 ± 2.84 | |
| 48-57[e] | 52 | 1.48 ± 3.52 | |
| 58-65[f] | 20 | 5.10± 6.26 | |
| **Level of education** | | | |
| None | 29 | 1.21 ± 3.79 | F=1.28 |
| Koranic | 338 | 0.66 ± 2.25 | p=0.27 |
| Primary | 137 | 0.23 ± 0.96 | |
| Secondary | 105 | 0.37 ± 2.31 | |
| Tertiary | 1 | 0.00 ± 0.00 | |
| **SES** | | | |
| Middle | 396 | 0.56 ± 2.12 | t=0.33 |
| Low | 216 | 0.50 ± 2.21 | p=0.74 |

Post hoc analysis
Age groups – ab , ac, bc , ad , cd, de - not significant

### 4.15 Association between oral health practices, oral hygiene status and mean tooth loss

Mean tooth loss experience in the participants was significantly associated with dental visitation using Student's t-test analysis (p=0.00). Women who had visited the dentist experienced greater tooth loss than those who had not (1.44±3.47 vs. 0.47±1.99 respectively), reflecting that dental visits are most likely associated with having symptomatic teeth that required extraction **(Table 4.46).**

The mean tooth loss varied proportionally with oral hygiene status and the difference was statistically significant between the three categories of oral hygiene status using post hoc analysis with Games-Howell multiple comparisons of means (p<0.05) **(Table 4.46)**.

Interestingly, there was an increase in mean tooth loss with increased frequency of tooth cleaning. Those who reported not cleaning at all had a mean tooth loss of $0.40 \pm 1.26$ while those who claimed to clean twice daily experienced $0.71 \pm 2.88$ tooth loss. However, those who cleaned more than twice daily had a lower mean of $0.42 \pm 1.70$. There was no statistically significant difference in the mean tooth loss by frequency of tooth cleaning using post hoc analysis with Games-Howell multiple comparisons of means ($p>0.05$). The reason for these contradictory results is not immediately apparent, but age and parity-related differences may be contributing factors **(Table 4.46).**

The use of fluoridated toothpaste was not significantly associated with tooth loss using Student's t-test analysis ($p>0.05$), although participants who reported the use of fluoride containing toothpaste experienced less tooth loss than those who did not ($0.41 \pm 1.92$ vs. $0.74 \pm 2.47$ respectively) **(Table 4.46).**

**Table 4.46 Mean tooth loss by oral hygiene status and oral health practices**

| Variables | N | Number of teeth lost Mean ± SD | Significance |
|---|---|---|---|
| **Oral hygiene status** | | | |
| Good[a] | 16 | 0.00 ± 0.00 | ab = 0.04** |
| Fair[b] | 193 | 0.27 ± 1.55 | ac =0.00** |
| Poor[c] | 403 | 0.68 ± 2.41 | bc =0.03** |
| **Frequency of tooth cleaning** | | | |
| I don't brush | 10 | 0.40 ± 1.26 | F=0.81 |
| Once daily | 73 | 0.59 ± 1.43 | p=0.49 |
| Twice a day | 208 | 0.71 ± 2.88 | |
| >Twice a day | 321 | 0.42 ± 1.70 | |
| **Fluoride in toothpaste** | | | |
| Yes | 379 | 0.41 ± 1.92 | t=0.96 |
| No | 233 | 0.74 ± 2.47 | p=0.08 |
| **Dental visit** | | | |
| Yes | 45 | 1.44 ± 3.47 | t=0.00 |
| No | 567 | 0.47 ± 1.99 | p=0.00* |

**Games-Howell multiple comparisons of means p-value

### 4.16 Association between BMI status and mean tooth loss

Mean tooth loss was proportional to increasing BMI scores. Underweight women experienced less tooth loss than normal and overweight/obese women. However, the difference was not statistically significant across the BMI statuses using post hoc analysis with Games-Howell multiple comparisons of means (F=2.08 p=0.13) (**Table 4.47**).

**Table 4.47 Mean tooth loss by BMI**

| BMI Categories | N (612) | Mean ± SD | Significance |
|---|---|---|---|
| Underweight[a] | 72 | 0.28 ± 0.99 | F=2.03 |
| Normal[b] | 409 | 0.48 ± 2.10 | p=0.13 |
| Overweight/obese[c] | 131 | 0.85 ± 2.68 | |

Post hoc analysis
ab, ac, bc – not significant

Mean tooth loss in parity groups varied proportionally with increasing BMI status. High parity women had greater tooth loss in all the BMI categories compared to low parity women. Interestingly, low parity underweight women did not experience any tooth loss while high parity underweight women had some missing teeth (0.83±1.64). Student's t-test analysis revealed statistically significant differences between both parity groups in normal and overweight/obese women (p=0.00 and p=0.01 respectively) (**Table 4.48**). Based on these results, the general association between tooth loss and BMI status seems be weak, but it is strong when parity groups are compared.

**Table 4.48 Mean tooth loss by BMI status and parity group**

| **BMI Categories** | **Low parity ≤4** | | **High parity ≥5** | | **p value** |
|---|---|---|---|---|---|
| | **N (342)** | **Mean ± SD** | **N (270)** | **Mean ± SD** | |
| Underweight | 49 | 0 | 23 | 0.83 ± 1.64 | |
| Normal | 237 | 0.10 ± 0.42 | 172 | 1.02 ± 3.14 | 0.00* |
| Overweight/obese | 56 | 0.13 ± 0.38 | 75 | 1.39 ± 3.44 | 0.01* |

## 4.17 Association between CPI scores and mean tooth loss

Mean tooth loss varied proportionally with increasing CPI scores from codes 0 through 3. Women with CPI scores of 0 did not experience any tooth loss while those with CPI 3 had the highest mean tooth loss of 2.04±4.29. There was no tooth loss observed in women with CPI 4. This may be due to the smaller sample size. Post hoc analysis with Games-Howell multiple comparisons of means shows statistically significant difference in the mean tooth loss in relation to CPI score (ac, ad, cd, de) (F=6.85 p=0.00) (**Table 4.49**).

**Table 4.49 Mean tooth loss by CPI scores**

| **CPI scores** | **N** | **Mean ± SD** | **Significance** |
|---|---|---|---|
| $0^a$ | 16 | 0.00 ± 0.00 | F=6.85 |
| $1^b$ | 177 | 0.28 ± 1.59 | p=0.00* |
| $2^c$ | 371 | 0.51 ± 1.97 | |
| $3^d$ | 46 | 2.04 ± 4.29 | |
| $4^e$ | 2 | 0.00 ± 0.00 | |

Post hoc analysis
Not significant - ab, ae, bc, bd, be, ce

### 4.18 Association between DMFT scores and mean tooth loss

There was no discernable pattern in the mean tooth loss of the women based on their DMFT scores. Women with a DMFT score ≥13 had the greatest mean tooth loss (2.67 ±2.52) while those with scores between 7 and 12 did not experience any loss of teeth. Analysis of multiple variance of means revealed that the differences in the mean tooth loss were statistically significant (F=18.54, p=0.00) (**Table 4.50**). These results indicate that the mean CPI and DMFT scores were associated with mean tooth loss in the participants.

**Table 4.50 Mean tooth loss by DMFT scores**

| DMFT scores | N | Mean ± SD | Significance |
|---|---|---|---|
| 0 | 366 | 0.24 ± 1.36 | F=18.54 |
| 1 | 83 | 1.19 ± 3.07 | p=0.00* |
| 2 | 68 | 0.51 ± 2.49 | |
| 3 | 26 | 1.38 ± 3.25 | |
| 4 | 33 | 1.30 ± 3.44 | |
| 5 | 17 | 1.24 ± 3.25 | |
| 6 | 7 | 0.14 ± 0.38 | |
| 7 | 2 | 0.00 ± 0.00 | |
| 8 | 4 | 0.00 ± 0.00 | |
| 11 | 1 | 0.00 ± 0.00 | |
| 12 | 1 | 0.00 ± 0.00 | |
| ≥ 13 | 4 | 2.67 ± 2.52 | |

Post hoc analysis could not be performed because at least one group had fewer than two cases

### 4.19 Regression analysis between socio-demographic variables, reproductive parameters, oral hygiene status and tooth loss

A linear regression (stepwise) was performed to predict the socio-demographic factors (age, SES, level of education), reproductive parameters (age at first, parity and duration of reproduction) and oral hygiene status that contribute to tooth loss. Model fitting was done and it showed a perfect fit (p=0.00). Women's age, duration of reproduction and parity were significantly associated with tooth loss (p<0.05 respectively) **(Table 4.51)**. Age accounted for 13.6% ($R^2$=0.136, p=0.00) of tooth loss in the population while duration of reproduction and parity contributed 1.2% ($R^2$=0.148, p=0.01) and 1.0% ($R^2$=0.158, p=0.01) respectively.

**Table 4.51 Linear regression of socio-demographic variables, reproductive parameters and oral hygiene status against tooth loss**

| Predictors | Unstandardized Coefficients B | Unstandardized Coefficients Std. Error | Sig. | 95.0% Confidence Interval for B Lower Bound | 95.0% Confidence Interval for B Upper Bound |
|---|---|---|---|---|---|
| (Constant) | -1.65 | .24 | .00 | -2.10 | -1.17 |
| Age | .07 | .01 | .00 | .06 | .08 |
| (Constant) | -1.97 | .26 | .00 | -2.49 | -1.46 |
| Age | .10 | .01 | .00 | .07 | .12 |
| Duration of reproduction | -.05 | .02 | .01 | -.09 | -.02 |
| (Constant) | -2.06 | .26 | .00 | -2.58 | -1.55 |
| Age | .09 | .01 | .00 | .07 | .12 |
| Duration of reproduction | -.09 | .02 | .00 | -.13 | -.04 |
| Parity | .12 | .04 | .01 | .03 | .20 |
| **Non-significant variables** | | | | | |
| | **B** | **T** | **Sig.** | **Partial Correlation** | |
| Age at first child birth | -.05 | -1.22 | .22 | -.051 | |
| Level of education | .04 | .99 | .32 | .042 | |
| Socio-economic status | .05 | 1.20 | .23 | .050 | |
| Oral hygiene status | -.03 | -.63 | .53 | -.026 | |

## 4.20 Regression analysis between reproductive parameters, DMFT score, CPI score and tooth loss

Linear regression (stepwise) was performed to predict the effects of age, parity, duration of reproduction, DMFT score and CPI score on tooth loss. Model fitting was done and it showed a perfect fit (p=0.00). Age, duration of reproduction and parity were significantly associated with tooth loss (p<0.05 respectively) (**Table 4.52**). Age accounted for 13.6% ($R^2$=0.136, p=0.00) of the variation in tooth loss while duration of reproduction and parity contributed 1.2% ($R^2$=0.148, p=0.01) and 1.0% ($R^2$=0.158, p=0.01) respectively.

**Table 4.52 Linear regression of age, parity, duration of reproduction, DMFT score and CPI score against tooth loss**

| Predictors | Unstandardized Coefficients | | Sig. | 95.0% Confidence Interval for B | |
|---|---|---|---|---|---|
| | B | Std. Error | | Lower Bound | Upper Bound |
| (Constant) | -1.636 | .236 | .000 | -2.099 | -1.173 |
| Age | .070 | .007 | .000 | .056 | .083 |
| (Constant) | -1.973 | .263 | .000 | -2.489 | -1.457 |
| Age | .096 | .012 | .000 | .073 | .118 |
| Duration of reproduction | -.050 | .018 | .005 | -.085 | -.016 |
| (Constant) | -2.062 | .263 | .000 | -2.580 | -1.545 |
| Age | .093 | .012 | .000 | .070 | .115 |
| Duration of reproduction | -.085 | .022 | .000 | -.127 | -.042 |
| Parity | .118 | .044 | .007 | .032 | .204 |
| **Non- significant variables** | | | | | |
| | **B** | **T** | **Sig.** | **Partial Correlation** | |
| DMFT score | .002 | .052 | .958 | .002 | |
| CPI score | -.037 | -.877 | .381 | -.036 | |

## 4.21 Early childhood caries (ECC)

### 4.21.1 Socio-demographic characteristics of the children

A total of 346 children aged less than 72 months participated in the study. Older children were not included in this analysis because the upper age limit for ECC is 71 months. The age distribution of the sample is provided in Table 4.47. The mean age was 22.09±16.23 months. The majority of the children were less than 24 months old (57.6%) and there were more females (54.9%) than males (45.1%). It is a cultural practice among the Hausa people to send the older male children away from the home to attend Koranic schools and as a consequence they were absent from the households. Only a small proportion of the children were first born or only children (9.8%). The majority of the children (67.9%) were of middle SES based on their mother's SES level (**Table 4.53**).

**Table 4.53 Socio-demographic characteristics of the children**

| Variables | N (%)<br>N=346 |
|---|---|
| **Age group (months)** | |
| ≤ 11 | 104 (30.1%) |
| 12-23 | 95 (27.5%) |
| 24-35 | 69 (19.9%) |
| 36-47 | 28 (8.1%) |
| 48-59 | 25 (7.2%) |
| 60-71 | 25 (7.2%) |
| **Sex** | |
| Male | 156 (45.1%) |
| Female | 190 (54.9%) |
| **Birth rank** | |
| First child/only child | 34 (9.8%) |
| Not first child/only child | 312 (90.2%) |
| **SES** | |
| Middle | 235 (67.9%) |
| Low | 111 (32.1%) |

### 4.21.2 Oral health of the children

The oral hygiene status of the children was generally fair (82.9%), although 11.3% had poor and 5.8% had good oral hygiene. The majority (73.4%) had their teeth cleaned twice or more daily with 22% reported as using fluoridated toothpaste. Virtually all the children (98.8%) had never been to the dentist (**Table 4.54**). This reflects poor utilization of oral health care services, even at early ages, unless urgent symptoms require attention.

**Table 4.54 Oral health practices of the children**

| Variables | N (%) N=346 |
|---|---|
| **Oral hygiene status** | |
| Good | 20 (5.8%) |
| Fair | 287 (82.9%) |
| Poor | 39 (11.3%) |
| **Frequency of tooth brushing** | |
| Twice or more daily | 254 (73.4%) |
| Less than twice a day | 92 (26.6%) |
| **Use of fluoridated toothpaste** | |
| Yes | 76 (22.0%) |
| No | 270 (78.0%) |
| **Dental visit** | |
| Yes | 4 (1.2%) |
| No | 342 (98.8%) |

### 4.21.3 Child nutritional data: breastfeeding and sugar consumption

As these were younger children, the extent to which they were breastfed is relevant to their nutritional status. Almost 60% were still breastfeeding beyond their first year of life.

As seen with the mothers, the consumption of sugar between meals was not particularly high for these young children. Approximately 45.0% of them consumed sugar three or more three times daily between meals (**Table 4.55**). This would not include any sugar added to beverages.

**Table 4.55 Duration of breastfeeding by child, and frequency of refined sugar consumption between meals**

| Variables | N (%) (N=346) |
|---|---|
| **Duration of breastfeeding** | |
| $\leq$12 months | 140 (40.5%) |
| >12 months | 206 (59.5%) |
| **Frequency of sugar consumption between meals** | |
| $\geq$3x per day | 154 (44.5%) |
| <3x per day | 192 (55.5%) |

## 4.22 Association between socio-demographic variables and ECC

The overall ECC experience (absence/presence) among the children was low with a prevalence of 3.2%. There was no discernable pattern between age and ECC in the children although there were more children aged 36-47 months with ECC (14.3%), followed by those aged 60-71 months (8.0%). None of the children in the cohorts $\leq$ 11 months and 48-59 months experienced caries. ECC was significantly associated with age group using Fisher's exact test analysis ($p<0.05$) (**Table 4.56**).

ECC is classified as severe (S-ECC) if there is any sign of smooth surface caries in children less than 3 years or when children age 36-47 months, 48-59 months and 60-71 months have dmft scores of greater or equal to 4, 5 and 6 respectively (Folayan *et al.*, 2015). The overall mean dmft score was low ($0.08\pm0.50$) with a range of 0 to 6, and the overall S-ECC rate was 0.9%. The prevalence of ECC was low among these children and there were few cases that were considered to be severe.

**Table 4.56 Frequency of ECC by age group**

| Age group (months) | N | ECC absent N (%) | ECC present N (%) | p-value |
|---|---|---|---|---|
| ≤ 11 | 104 | 104 (100.0%) | 0 (0%) | 0.003* |
| 12-23 | 95 | 91 (95.8%) | 4 (4.2%) | |
| 24-35 | 69 | 68 (98.6%) | 1 (1.4%) | |
| 36-47 | 28 | 24 (85.7%) | 4 (14.3%) | |
| 48-59 | 25 | 25 (0%) | 0 (0%) | |
| 60-71 | 25 | 23 (92.0%) | 2 (8.0%) | |
| **Total** | **346** | **335 (96.8%)** | **11 (3.2%)** | |

**Table 4.57** provides information on the association between socio-demographic factors (sex, SES and birth rank) and ECC. Only birth rank was significantly associated with the presence of ECC (Fisher's exact test, $p<0.05$). None of the children who were the first or only child had caries, but 3.5% of the other children did ($p=0.00$).

Fisher's exact test analysis did not reveal a statistically significant association between sex, SES and the proportion of children with ECC ($p>0.05$ respectively). More females than males experienced ECC (4.7% vs. 1.3%). More children of low SES had caries than those of middle SES (3.6% vs. 2.9%) (**Table 4.57**).

**Table 4.57 Association between socio-demographic variables and ECC**

| Variables | ECC absent N (%) | ECC present N (%) | Total N (%) | p-value |
|---|---|---|---|---|
| **Sex** | | | | |
| Male | 154 (98.3%) | 2 (1.3%) | 156 (100.0%) | 0.07 |
| Female | 181 (95.3%) | 9 (4.7%) | 190 (100.0%) | |
| **SES** | | | | |
| Middle | 228 (97.1%) | 7 (2.9%) | 235 (100.0%) | 0.76 |
| Low | 107 (96.4%) | 4 (3.6%) | 111 (100.0%) | |
| **Birth rank** | | | | |
| First child/only child | 34 (100.0%) | 0 (0%) | 34 (100.0%) | 0.00* |
| Not first child/only child | 301 (96.5%) | 11 (3.5%) | 312 (100.0%) | |

### 4.23 Association between oral health practices and nutritional parameters and ECC

Interestingly, children who used fluoridated toothpaste had higher caries counts than those who did not (7.9% vs. 1.9%). The reason for this is not clear however the fluoride content of the toothpaste may be substandard. Only one child of the four who visited the dentist experienced caries compared to 2.9% who had had never visited the dentist. Dental visitation in children is possibly to seek treatment for painful teeth. A Fisher's exact test revealed that the use of fluoridated toothpaste and dental visitation were significantly associated with ECC in the children ($p<0.05$ respectively) (**Table 4.58**).

The oral hygiene status and frequency of tooth cleaning were not significantly associated with ECC using a Fisher's exact test ($p>0.05$ respectively). None of the children with good oral hygiene experienced caries, yet only 3.5% of children with fair oral hygiene and 2.6% of those with poor oral hygiene had caries. There was little difference in the caries experience of children who cleaned their teeth twice or more and those who cleaned less frequently (**Table 4.58**).

**Table 4.58 Association between oral health practices and ECC**

| Variables | ECC absent N (%) | ECC present N (%) | Total N (%) | p-value |
|---|---|---|---|---|
| **Oral hygiene status** | | | | |
| Good | 20 (100.0%) | 0 (0%) | 20 (100.0%) | 0.67 |
| Fair | 277 (95.5%) | 10 (3.5%) | 287 (100.0%) | |
| Poor | 38 (97.4%) | 1 (2.6%) | 39 (100.0%) | |
| **Frequency of tooth brushing** | | | | |
| Twice daily or more | 246 (96.9%) | 8 (3.1%) | 254 (100.0%) | 1.71 |
| Less than twice a day | 89 (96.3%) | 3 (3.3%) | 92 (100.0%) | |
| **Use of fluoridated toothpaste** | | | | |
| Yes | 70 (92.1%) | 6 (7.9%) | 76 (100.0%) | 0.01* |
| No | 265 (98.1%) | 5 (1.9%) | 270 (100.0%) | |
| **Dental visit** | | | | |
| Yes | 3 (75.0%) | 1 (25.0%) | 4 (100.0%) | 0.01* |
| No | 332 (97.1%) | 10 (2.9%) | 342 (100.0%) | |

The duration of breastfeeding was related to caries experience in the children. Children who were breastfed for $\leq$12 months (including those who were less than one year old) did not experience caries while those breastfed for more than 12 months (5.3%) had caries. A Fisher's exact test showed a significant association between duration of breastfeeding and ECC (p=0.01). The age differences between the groups may underlie differences in the potential for caries development.

The frequency of sugar intake between meals was not significantly associated with caries in the children (Fisher's exact test, p>0.05). Children who consumed sugar less than three times daily between meals had higher caries counts than those with increased frequency of sugar consumption (3.8% vs. 2.6%) (**Table 4.59**).

**Table 4.59 Association between breastfeeding duration, frequency of refined sugar intake and ECC**

| Variables | ECC absent N (%) | ECC present N (%) | Total N (%) | p-value |
|---|---|---|---|---|
| **Duration of breastfeeding** | | | | |
| ≤12 months | 140 (100.0%) | 0 (0%) | 140 (100.0%) | 0.01* |
| >12 months | 195 (94.7%) | 11 (5.3%) | 206 (100.0%) | |
| **Frequency of sugar consumption between meals** | | | | |
| ≥3x per day | 150 (97.4%) | 4 (2.6%) | 154(100.0%) | 0.35 |
| <3x per day | 185 (96.4%) | 7 (3.8%) | 192 (100.0%) | |

### 4.24 Regression analysis between socio-demographic factors and ECC

Binary logistic regression was performed to determine the socio-demographic factors (child's age, sex, SES and child's birth order) that contributed to caries experience in the children. Model fitting was done and it showed a perfect fit using the Hosmer and Lemeshow test. Only the child's age was significantly associated with ECC experience (p=0.04) **(Table 4.60).**

**Table 4.60 Binary regression of socio-demographic factors against ECC**

| Predictors | B | S.E. | Sig. | Exp(B) | 95% CI for EXP(B) Lower | 95% CI for EXP(B) Upper |
|---|---|---|---|---|---|---|
| Male | -1.20 | .80 | .13 | .30 | .06 | 1.44 |
| Child's position | -.09 | .13 | .47 | .91 | .71 | 1.18 |
| SES (middle) | -.19 | .65 | .77 | .83 | .23 | 2.96 |
| Age | .03 | .02 | .04 | 1.03 | 1.00 | 1.07 |
| Constant | -3.47 | .89 | .00 | .03 | | |

### 4.25 Regression analysis between oral health practices and ECC

Binary logistic regression was performed to determine the oral health practices (frequency of tooth cleaning, frequency of sugar consumption between meals, use of fluoridated toothpaste and dental visit) that contributed to caries experience in the children. Model fitting was done and it showed a perfect fit using the Hosmer and Lemeshow test. Only the use of fluoridated toothpaste was significantly associated with ECC experience in the children (p=0.01) **(Table 4.61).**

**Table 4.61 Binary regression of oral health practices against ECC**

| Predictors | B | S.E. | Sig. | Exp(B) | 95% CI for EXP(B) | |
|---|---|---|---|---|---|---|
| | | | | | Lower | Upper |
| Dental visit | 1.91 | 1.25 | .13 | 6.74 | .58 | 78.06 |
| Tooth brushing once a day | -16.98 | 7513.57 | 1.00 | .00 | .00 | . |
| Tooth brushing x2 a day | .86 | .87 | .32 | 2.36 | .43 | 12.91 |
| Tooth brushing $\geq$ 2 a day | .53 | .77 | .49 | 1.70 | .38 | 7.73 |
| Fluoride in toothpaste | 1.73 | .69 | .01 | 5.65 | 1.47 | 21.72 |
| Always consume sugar between meals | 18.10 | 6714.06 | 1.00 | 72502280.64 | .00 | . |
| Sometimes consume sugar between meals | 17.89 | 6714.06 | 1.00 | 58634464.58 | .00 | . |
| Rarely consume sugar between meals | 17.247 | 6714.061 | 1.00 | 30933247.89 | .00 | . |
| Constant | -22.11 | 6714.06 | 1.00 | .00 | | |

### 4.26 Maternal factors and predisposition to caries in children

**Table 4.62** provides information on maternal factors that may predispose a child to caries. The majority of the mothers of these young children were of low parity (63.0%) and approximately 66.0% of them were caries-free. Mechanisms for mother–child transfer of cariogenic bacteria was assessed through the practices of kissing on the mouth, provisioning with premasticated food, or the shared use of utensils. Mother to child kissing during the first year of life was reported for 57.2% of the dyads, while

39.9% of the mothers fed their child with premasticated food. Almost 60% of the mothers reported sharing utensils (spoons and cups) with the child in the first year of life (**Table 4.62**). Thus the proportion of mothers in the studied dyads with caries was low, while the potential for bacterial transfer via kissing or utensils was relatively high.

**Table 4.62 Maternal caries risk factors**

| **Variables** | **N (%) (N=346** |
|---|---|
| **Parity group** | |
| Low parity ≤4 | 218 (63.0%) |
| High parity ≥ 5 | 128 (37.0%) |
| **Caries in mothers** | |
| Yes | 119 (34.4%) |
| No | 227 (65.6%) |
| **Mother/child kissing during first year** | |
| Yes | 198 (57.2%) |
| No | 148 (42.7%) |
| **Feeding premasticated food by mother during first year** | |
| Yes | 138 (39.9%) |
| No | 208 (60.1%) |
| **Sharing of utensils during first year** | |
| Yes | 202 (58.4%) |
| No | 144 (41.6%) |

### 4.26.1 Association between maternal caries risk factors and ECC

**Table 4.63** provides information on the association between maternal caries risk factors (parity, presence of caries in the mother and mother to child feeding habits) and presence of ECC. The presence of caries in the mother and feeding of premasticated food were significantly associated with caries experience in the child (Fisher's exact tests $p<0.05$ respectively). Thirty-four percent of the mothers were caries active. Of these, approximately 6.0% were mother-child dyads with caries.

Children whose mothers were caries active experienced ECC more than children whose mothers were caries-free (5.9% vs. 1.8%, p=0.04). Unexpectedly, the proportion of children with caries was significantly greater in children who were not fed premasticated food by their mothers (4.8% vs. 0.7%, p=0.03).

Parity, mother to child kissing during first year of life and sharing of utensils between mother and child in the first year of life were not associated with ECC using Fisher's exact test analysis (p>0.05). There was no difference in the ECC proportion of children whose mother was of high parity and those of low parity mothers (3.1% vs. 3.2% respectively). The trend is similar for mother to child kissing. Regarding sharing of utensils (spoons and cups), approximately 4.0% of children whose mother did not share feeding utensils had caries compared to 3.0% whose mother did share feeding utensils (**Table 4.63**).

The data on maternal caries risk factors and ECC suggest that presence of caries in the mother was associated with caries experience in the child but the proposed mechanisms of direct transmission are not responsible for caries dyads.

**Table 4.63 Association between maternal caries risk factors and ECC**

| Variables | ECC absent N (%) | ECC present N (%) | Total N (%) | p-value |
|---|---|---|---|---|
| **Parity** | | | | |
| ≤5 | 211 (96.8%) | 7 (3.2%) | 218 (100.0%) | 0.96 |
| ≥ 5 | 124 (96.9%) | 4 (3.1%) | 128 (100.0%) | |
| **Caries in mothers** | | | | |
| Yes | 112 (94.1%) | 7 (5.9%) | 119 (100.0%) | 0.04* |
| No | 223 (98.2%) | 4 (1.8%) | 227 (100.0%) | |
| **Mother to child kissing during first year** | | | | |
| Yes | 192 (97.0%) | 6 (3.0%) | 198 (100.0%) | 0.86 |
| No | 143 (96.6%) | 5 (3.4%) | 148 (100.0%) | |
| **Feeding child premasticated food by mother during first year** | | | | |
| Yes | 137 (99.3%) | 1 (0.7%) | 138 (100.0%) | 0.03* |
| No | 198 (95.2%) | 10 (4.8%) | 208 (100.0%) | |
| **Sharing of utensils in the first year** | | | | |
| Yes | 196 (97.0%) | 6 (3.0%) | 202 (100.0%) | 0.79 |
| No | 139 (96.5%) | 5 (3.5%) | 144 (100.0%) | |

### 4.27 Regression analysis between maternal caries risk factors and ECC

Binary logistic regression was also performed to determine whether the maternal factors (parity, presence of maternal caries, mother to child kissing, premastication, sharing of utensils), duration of breastfeeding and child's oral hygiene status contributed to the caries experience of the children. Model fitting was done and it showed a perfect fit using the Hosmer and Lemeshow test. Only premastication of food was significantly associated with ECC experience (p=0.048) **(Table 4.64).** Notably, maternal caries was not associated with caries experience in the children.

**Table 4.64 Binary regression of maternal caries risk factors, child's oral hygiene status against ECC**

| Predictors | B | S.E. | Sig. | Exp(B) | 95% CI for EXP(B) | |
|---|---|---|---|---|---|---|
| | | | | | Lower | Upper |
| Parity | -.03 | .14 | .838 | .97 | .74 | 1.28 |
| Presence of caries | .15 | .09 | .100 | 1.16 | .97 | 1.38 |
| Mother/child kissing | .52 | .70 | .459 | 1.68 | .43 | 6.62 |
| Feeding of premasticated food | -2.23 | 1.13 | .048 | .12 | .01 | .98 |
| Sharing of utensils | .20 | .72 | .784 | 1.22 | .30 | 4.97 |
| Duration of breastfeeding | .01 | .02 | .684 | 1.01 | .98 | 1.04 |
| Oral hygiene status (fair) | -17.21 | 8619.20 | .998 | .00 | .00 | . |
| Oral hygiene status (poor) | .53 | 1.08 | .626 | 1.70 | .20 | 14.12 |
| Constant | -3.93 | 1.29 | .002 | .02 | | |

**Part 2: Qualitative study (Published in *PLOS ONE, see Appendix 1*)**

### 4.28 Socio-demographics of focus group discussion (FGDs) participants

Thirty-three women participated in the focus group discussions (FGDs). Their ages ranged between 19 to 66 years with a mean age of 40.82$\pm$14.99 years. More than half (54.5%) of the respondents had no formal education. Eighteen (54.5%) had five or more children. The mean parity was 4.48$\pm$3.00. There was a significant difference between the mean parity levels by age group (p=0.002). The majority of the women (78.8%) were small-scale informal traders in the market and the remainder (21.2%) were housewives (**Table 4.65**).

**Table 4.65 Socio-demographic characteristics of FGDs participants**

| **Characteristics** | **Total N=33** |
|---|---|
| **Age (years)** | |
| 19-30 | 11 (33.3%) |
| 31-45 | 12 (36.4%) |
| 46-66 | 10 (30.3%) |
| **Level of education** | |
| Koranic only | 18 (54.5%) |
| Primary (partial or completed) | 5 (15.2%) |
| Secondary (partial or completed) | 10 (30.3%) |
| **Number of children (living)** | |
| $\leq$ 4 | 15 (45.5%) |
| 5-8 | 14 (42.4%) |
| > 8 | 4 (12.1%) |
| **Mean parity by age cohorts** | |
| 19-30 | 2.18 $\pm$ 1.60 |
| 31-45 | 6.25 $\pm$ 2.22 |
| 46-66 | 4.90 $\pm$ 3.51 |
| | P=0.002 |
| Mean age (years) | 40.82 $\pm$ 14.99 |
| Mean parity | 4.48 $\pm$ 3.00 |
| **Occupation** | |
| Traders | 26 (78.8%) |
| Housewives | 7 (21.2%) |

### 4.29 Key findings and interpretation

The findings from this study reflect the beliefs and thoughts of Hausa women of childbearing and post childbearing ages. The themes included “Perception on the relationship between tooth loss and childbearing”, “Beliefs about tooth loss”, “Causes of tooth loss”, and “Effects of tooth loss on women”.

The network diagram (**Figure 4.2**) shows the perceived causes of tooth loss among Hausa women of childbearing and post-childbearing age. These etiologies include dirty mouth, vomiting during labor, excessive sugary diet, aging, food impaction, tooth worm infection and hole in the tooth, drinking cold water, road traffic accidents, other accidents, fights, extractions or loss due to poor tissue support and cancer. These causes are further described below.

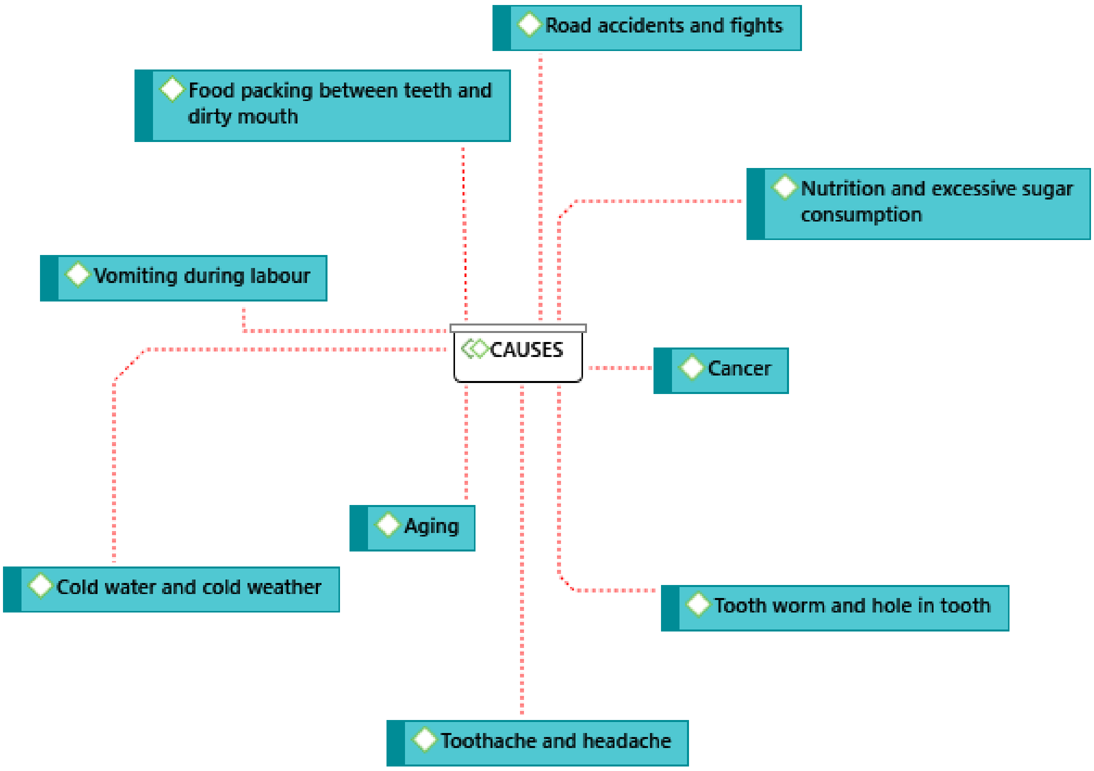


**Figure 4.5 Causes of tooth loss**

**Poor oral hygiene**

Respondents identified poor oral hygiene as a major cause of tooth loss among women. Because most women do not practice good dental care, they have tooth decay and tooth loss. Kolanut, a mild stimulant chewed to restore vitality and reduce hunger pangs, results in staining of teeth and was associated with poor oral hygiene.

> *….because of dirty mouth and kolanut chewing. Kolanut turn the colour of the teeth bad and make them dirty*

***…..R3, REC 013, Hausa community***

*…. Some women are unable to take care of their teeth because they do not care about the mouth*

***…..R2, REC 010, Hausa community***

*…..lack of brushing the teeth will make them fall out.*

***….. R1, REC 012, Hausa community***

*………poor personal cleaning make the mouth to smell after sometime the teeth will be shaking and fall out.*

***….. R5, REC 015, Hausa community***

**Food impaction, tooth worm infection and caries**

It was also discovered during the discussions that food impaction, inadequate dental care during pregnancy, and worms infesting the oral cavity lead to tooth loss. Worms create the holes seen in teeth, cause caries, make the teeth weak and eventually they are lost. Below are responses to support these points:

*….meat impaction between teeth.*
*… .Hole made by worms*

***…..R3&R5, REC 015, Hausa community***

*…Tooth worms eat the tooth and make a hole in it. This cause tooth pain*
*…Tooth worms make holes in teeth and cause pain*
*… I hear traditional medicine people say that tooth worm make holes in teeth and later gives pain and the tooth will be removed*
*……dirty mouth have worms that damage the teeth*

***…..R1, R2, R3 & R4 REC 011, Hausa community***

**Aging**

Discussants stated that women age faster than men due to childbearing and domestic chores. These cause them to lose their teeth earlier than men.

*…..Women become old earlier than men and it is because of childbearing. Because of this women lose more teeth than men*

*…..My friend who left the city for the village now has missing teeth maybe because she works more and she is not able to take care of her body. She is going to become old earlier than the people in the city.*

***…..R2 & R3  REC 012, Hausa community***

*…..as you grow old the teeth are no more strong, they are weak and will fall out one by one*

***……R6, REC 011 Hausa community***

**Nutrition and excessive sugar consumption**

Furthermore, it was mentioned during the course of the discussion that pregnant women enjoy eating excessive sugar and sugary foods. This leads to weak teeth, causing toothache and easy loss of the teeth. It was unanimously agreed that women mostly lose more teeth than men because of excessive sugar consumption.

> *.....maybe she chew gums which contains sugar and can cause tooth hole and tooth loss.*
>
> ***.....R2, REC 012, Hausa community***
>
> *....consumption of sugar coating food make holes in teeth*
> *.....consumption of honey, it is sweet and can cause holes in teeth*
>
> ***.....R2& R6, REC 013, Hausa community***
>
> *.....girls like to eat sweets and chew gum, these make the teeth go bad. They cause holes and pain and the teeth are removed later*
>
> ***.....R1, REC 011, Hausa community***

**Cancer**

Respondents suggested that women of childbearing age could lose their tooth if they have cancer of the month.

> *....Maybe the women that lost teeth have cancer*
>
> ***..... R6, REC 010, Hausa community***
>
> *.... Cancer, big or small makes the teeth to be shaking and fall after some time*
>
> ***....... R1, REC 014, Hausa community***

**Other causes of tooth loss**

Respondents offered that using the teeth to open bottled drinks could cause pain/trauma leading to loss of teeth. In addition, it was mentioned that teeth can be lost through fights or road traffic accidents and can also fall off by themselves (perhaps due to periodontal disease) or through extraction.

> *..... using teeth to open drink/ Coca-Cola crown tops or biting something hard. The tooth can break or fall out*
> *...... "Okada" (motorcycle) or car accidents can make teeth fall out if you hit you mouth on the"Okada"or ground*
>
> ***..... R2, REC 015, Hausa community***
>
> *.... My tooth was removed because of pain. There was a hole in it.*
> *....Yes, my tooth came out on it own. It was shaking before it fell off*
>
> ***..... R2& R3, REC 010, Hausa community***

*...punch or slap on the face from fights between two people can make teeth fall off*

***.......R4, REC 013, Hausa community***

Furthermore, it was mentioned that ingestion of cold water and cold weather could lead to tooth loss.

*...... drinking cold water and cold weather......*

***..... R6, REC 011, Hausa community***

**4.29.2 Effects of losing teeth**

Discussants described the effects of tooth loss in women of childbearing age as including esthetic decline, loss of self-esteem, eating and chewing difficulties, and financial burden.

Respondents said that tooth loss affects their self-esteem. Sometimes they lose their joy and are unable to speak in public and smile because of the shame of their lost tooth.

*R2: Very painful associated with missing of joy because you cannot talk or laugh like you want to in public*

***..... R2, REC 014, Hausa community***

*R3: Esthetic problem [I can't laugh well because the gap (edentulous space) will show]*

***..... R3, REC 010, Hausa community***

*R3: Esthetic/ loss of self-esteem [I don't like to laugh or talk in public so that people will not laugh at me]*
*R5: It affects the beauty [when you lose your front teeth you don't look beautiful again]*
*R6: Unable to smile*

***..... R3,R5 &R6 REC 012, Hausa community***

In addition, tooth loss makes eating and chewing difficult for them. It was noted during the course of discussion that tooth loss causes pain and discomfort during mastication.

*... difficulty in eating/ chewing – I am unable to chew meat or maize, I miss out on them*
*.......anytime I try to chew meat or maize, it is discomforting when the food is on the gum at the back where there are no teeth. I don't enjoy it.*
*.....because it is front teeth I don't have difficulty in chewing but I don't feel pretty like I was when the teeth were there.*

***..... R3&R5 REC 011, Hausa community***

Finally, respondents complained about the financial burden to replace their teeth when they lose them. They mentioned that it is expensive to replace missing teeth.

> …..unable to chew and to replace with artificial teeth you have to pay money [Financial burden]
>
> ***….. R1, REC 011, Hausa community***

### 4.29. 3 Perceptions and beliefs on the relationship between parity and tooth loss

Respondents were unanimous in their belief that there is a relationship between tooth loss and childbearing (**Figure 4.3**).

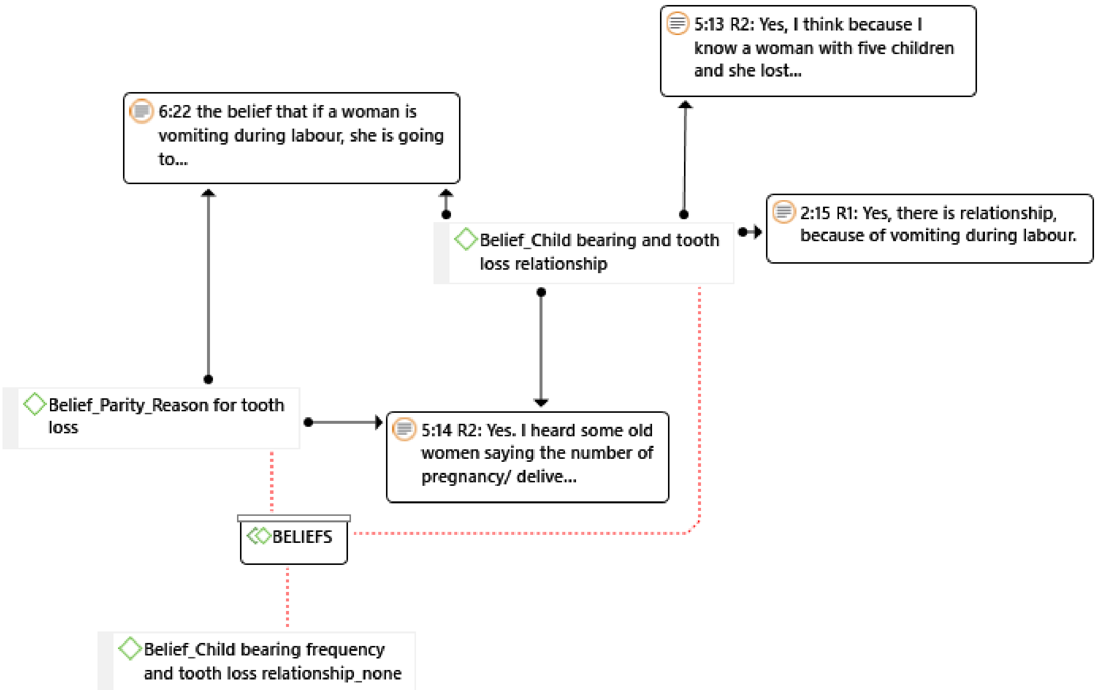


**Figure 4.6 Thematic beliefs of women on the relationship between parity and tooth loss**

Respondents said that during the course of labour, women vomit, which makes their teeth weak and results in tooth loss. Excerpts from interactions with the respondents include:

> …..*Yes. I think because I know a woman with five children and she lost some teeth.*
>
> ***…..R2, REC 015, Hausa community***
>
> ……*Vomiting during labour in female, which will make the teeth weak and will not last. Yes, I am having vomiting during labour and only one tooth lost after menopause.*

***…..R2, REC 010, Hausa community***

*….Yes, I do vomit during labour and I lost my tooth [two teeth]*

***…..R3, REC 012, Hausa community***

*…We heard that when women are having vomiting during labour their teeth are not going to last.*

***…..R1, REC 013, Hausa community***

*.. I vomited during labour but did not lose a tooth but I am afraid that I will lose one soon or later*

***……R4, REC 014, Hausa community***

*…. I know that pregnancy will cause lose of hair, nail, tooth. It also causes pain in tooth. When I was pregnant I lost my hair but not my tooth or nail.*

***……R5, REC 011, Hausa community***

*…….the number of pregnancy that a woman has is the number of teeth she will lose.*

***…… R6, REC, 016, Hausa community***

**……..** *I lost a tooth because I vomited when I was in labour*

***……..R7, REC, 015 Hausa community***

During the course of the discussion, respondent gave a local phrase "*payar baka"* for this condition. Quotes to buttress this are:

*…… Vomiting during labour [payar baka]*

***….. R1, REC 010, Hausa community***

….. I vomited when I was going to have my last child and my tooth fell off

***……. R3 REC 013 Hausa community***

However, some respondents believed there is no relationship between tooth loss and child bearing. Excerpts from interaction with the respondents are shown below:

*….. (Q: Any relationship between parity and tooth loss?). It's not due to pregnancy. It's due to guava seed impaction between the teeth but that happened during pregnancy, I have 12 children without losing any tooth.*

***…..R1, REC 012, Hausa community***

*……. I lost some teeth before I marry so it cannot be pregnancy that cause it since I was not pregnant before I marry*

***……..R3, REC 014 Hausa community***

*…… No (Q7: Is there any relationship between the number of children women have and the number of teeth lost is there any relationship?)*
*….. No [unanimously]*

***…..R1&6, REC 011, Hausa community***

Some respondents stated that tooth loss is not associated with pregnancy or childbirth. It emerged that this belief was based on the observations that young girls can also have tooth decay that leads to tooth loss. Excerpts from interactions with the respondents are provided below:

*……some women also have holes in teeth associated with tooth loss but not really associated with childbearing. Because even a very young girl can have holes in teeth associated tooth lost.*
*…….I lost some teeth before I marry or even have children. It cannot be pregnancy maybe the sweets and chewing gum I took when I was young.*

***…..R6 & R7 REC 010, Hausa community***

# Chapter 5

## Discussion

This study investigated the relationship between number of children and tooth loss among Hausa women in rural districts of Kano State, Nigeria. This is the first mixed methods study on the subject in a population with many high parity women. The selected methodology proved to be effective for eliciting new information, documenting the effects of parity and highlighting Hausa women's beliefs regarding their oral health.

Quantitative research methods are often poor choices for providing information on the context in which people behave or their beliefs. A qualitative approach can offset this. In this study, we were able to characterize the quantitative oral health profile of a sample of Hausa women. Age, parity and duration of reproduction were strongly associated with tooth loss. Increased age was associated with fewer remaining teeth, and women of higher parity and a longer span of reproductive years experienced more tooth loss. Although Hausa women do not have high levels of caries, their caries are related to parity status. However, their caries risk behaviours do not include extreme sugar consumption and their explanations of tooth loss suggest that other factors are probably important for explaining tooth loss in the population.

The majority of studies on parity and tooth loss fail to include higher parity women and to consider important confounding factors that need to be controlled. Our study carefully considered these factors as they potentially distort or influence the true association between parity and tooth loss. Women of different parity levels, including great grand multiparty ($\geq$10 live births and stillbirths), were included to fully investigate the cumulative effects of successive pregnancies on maternal oral health. We also considered reproductive parameters (age at first birth and duration of birth interval) that can contribute to stress during the reproductive years. Furthermore, participants' oral hygiene status and utilization of dental services were considered because of their associations with caries and periodontitis-- the chief conditions underlying tooth loss.

## 5.1 Parity and tooth loss

Parity was positively associated with tooth loss in Hausa women. As expected, high parity women experienced significantly greater tooth loss. Importantly, the duration of reproduction (the span of reproductive years), was found to be a critical contributor. Women of longer duration of reproduction lost significantly more teeth. Not surprisingly, our study also found that age was strongly associated with tooth loss.

Although a negative correlation was noted between high parity, duration of reproduction and the number of teeth present in the mouth, it is not possible to attribute this entirely to the effect of parity. This is because age, duration of reproduction and tooth loss are all time-dependent variables. Older women have greater possibilities for higher parity as well as increased potential for exposure to cariogenic bacteria and periodontal disease conditions. The cumulative effect of parity on tooth loss is more apparent in the older age cohorts for this reason. This issue is illustrated by two studies that found no association between parity and tooth loss in African women (Walker *et al*., 1983; Scheutz *et al*., 2002). While these researchers also included higher parity women in their samples, unlike our study they failed to include older women and were therefore only able to evaluate the early effects of parity. While our methodology enabled us to explore the association between parity and tooth loss on a more comprehensive level, a longitudinal study of a population with high parity women is needed to establish a cause and effect relationship between parity and tooth loss.

Generally, tooth loss experience in our participants was low. This may be related to the low levels of caries experience and severe periodontal disease. These two conditions are the principal causes of tooth loss, and if untreated they can ultimately lead to tooth loss. The low caries rate may be connected to low intake of refined sugar in Hausa women. Although their oral hygiene status was generally poor, the severity of periodontal disease, as measured by periodontal pockets, was low. The reason for this is unclear, as high levels of periodontal disease are typically associated with poor oral hygiene and infrequent use of dental services. One possible explanation may be that there are abrasive materials or other characteristics of the traditional Hausa diet that moderate the periodontal risks.

In our study, we controlled for the effects of various confounders (age inclusive) for tooth loss through regression analysis. Although age, duration of reproduction and parity significantly contributed to tooth loss in the population, the percent contribution differs for these factors with the highest being associated with age and the lowest with parity.

### 5.2 Perceptions of Hausa women on parity and tooth loss

Hausa women typically have high parity, and this results in their perception of the consequences of high parity as normal and unexceptional. Generally, the women in this study did not perceive that the number of children is directly associated with tooth loss. However, they associated pregnancy itself with tooth loss through the belief that a woman is predisposed to lose a tooth or at risk of losing one in future if she vomits during childbirth-- a condition termed “payar baka”. Tooth attachments weakened due to gingival and periodontal diseases are more likely to fall off with forceful expulsion of gastrointestinal content through the mouth, during labour. A review of the literature did not yield any information on the link between vomiting during labour and tooth loss.

Hausa women perceived other causes of tooth loss to be dirty mouth, tooth worm, ageing and sugar cravings. Dirty mouth is associated with plaque and calculus deposits, which are related to gingivitis and periodontitis and may lead to tooth loss. Historically and traditionally tooth worm was linked to tooth decay and gum disease, although this notion has been debunked. It is possible that the Hausa women still hold on to this concept because of the presence of Guinea worm, as well as intestinal worms, in their environment. Further support for this is reflected in their association of cold water (the medium for Guinea worm proliferation is deep wells) with tooth loss.

Ageing is another reason the women in our study attributed to tooth loss. They perceived that women age faster than men because of the stress associated with childrearing and domestic chores. Ageing is related to tooth wear, decay, periodontal disease and debilitating health conditions such as diabetes that may compromise oral health status. Furthermore, the women perceived that sugar cravings, especially chewing gum, were related to tooth loss although their dietary sugar consumption was low. Generally, Hausa women viewed tooth loss through a filter of both traditional (*payar baka*, tooth worm and sugar cravings) and modern dental (dirty mouth) perspectives. It is important that adequate and frequent oral health education is carried out in the population to address the existing beliefs and improve oral health behaviour.

### 5.3 Relationship between parity and caries in Hausa women

This study provides the first evidence that parity is positively associated with caries experience in an African population. Higher parity women experienced significantly more caries than lower parity women irrespective of their socio-economic status and oral health practices. It has been argued that the cumulative deficiencies of repeated pregnancies (commonly termed Maternal Depletion Syndrome) are associated with calcium depletion from teeth that results in caries formation. As there is currently no substantiation for calcium loss in teeth via this proposed syndrome, a more probable explanation for increased caries levels is the effect of hormones on the oral environment. Estrogen levels are highest during pregnancy and are associated with reduction in saliva flow and buffering capacity, and increased growth of cariogenic bacteria (Salvolini *et al*., 1998; Lukacs and Largaespada, 2006). These factors promote caries, especially where there is inadequate oral hygiene. Consequently, the hormonal effects of repeated pregnancies may result in increased caries rates.

Russell *et al*. (2010) reported that higher parity women had elevated untreated caries rates compared to lower parity women regardless of socio-economic status, race, and age. Although their findings are similar to ours, there are major differences in the characteristics of the study populations. Their US sample was diverse in ethnicity, consisting of White and Black non-Hispanic women, and the majority of the participants were of low parity and had access to dental care. The women in our study were ethnically homogeneous and had fairly similar levels of dental health care access and utilization. Use of treatment services was very low for both low and middle-income women and reflected similar behaviours involving delayed treatment with extraction as the typical outcome.

Two studies from Africa did not identify any relationship between parity and caries. Walker *et al*. (1983) observed no difference in the caries rates of higher and lower parity rural Black South Africa women. Similarly, Scheutz *et al*. (2002) failed to detect an association between parity and caries in Tanzanian women. The differences between those African studies and ours are likely to be due to the sample demographics. Women above 50 years and 55 years were excluded from the Tanzanian and South African studies respectively (Walker *et al*., 1983; Scheutz *et al*., 2002). Similar to the situation with tooth loss, the cumulative effects of high parity on caries are likely to be more obvious in the older age groups. Consequently, the results of these two studies may not be a true reflection of the relationship between parity and caries in African women.

Caries frequencies in African populations are low compared to other world regions. Caries formation is influenced by a complex interplay of factors that include bacteria plaque, sugar, susceptible tooth surface area and duration of exposure. Among these, consumption of refined sugars is the single most important dietary factor in the establishment of caries (Holm, 1990). Frequency of refined sugar consumption between meals is more implicated in caries formation than sugar consumed during meals. The Vipeholm study documented that individuals who frequently consumed refined sugar between meals had significant increases in caries experience (Gustafsson *et al*., 1954). The refined sugar consumption of the Hausa women was low. This may explain their overall low caries incidence. The indigenous rural African diet does not support caries formation as it is primarily comprised of homemade foods that are low in refined sugars (Cote *et al*., 2004; Enwonwu *et al*., 2004). The Hausa diet consists of grains that are rich in starch. Presently, the role of high starch diets in caries formation remains unclear, although it has been documented that salivary enzymes convert the starch in foods to glucose in very small amounts (Enwonwu *et al*., 2004). There is some evidence suggesting that starch-rich dietary staples are associated with low caries experience (Moynihan, 2005). In addition, hard and coarse diets can modify the occlusal morphology of molars. The effects would be more pronounced for teeth with low surface relief and thin enamel. Enamel thickness is associated with the caries process, with thicker enamel being less susceptible to caries (Daubert *et al*., 2016). Black Americans were found to have thicker enamel than White Americans (Harris *et al*., 2001; Daubert *et al*., 2016), implying they might have greater caries resistance. Further research is needed on enamel thickness in African populations and how it figures into the reported low prevalences of caries in Africans, particularly those subsisting on traditional diets with little processed foods (Thorpe, 2006).

We also found that age was strongly associated with caries in the sample. The older an individual is, the greater the potential exposure of the teeth to the oral environment and cariogenic factors (refined sugar and *Streptococcus mutans*) that favour caries formation. In addition, the ability to adequately remove plaque, a medium for *Streptococcus mutans,* is lessened due to reduced ability of fine hand and arm movements in old age (Razak *et al*., 2014). While age influences both caries and parity, parity still contributed significantly to caries experience in the Hausa women. The difference in caries rate by parity observed in this study may be more associated with hormonal (estrogen) levels and poor oral hygiene practices than frequency of refined sugar consumption.

### 5.4 Relationship between parity and periodontal status

Parity was not associated with periodontal status in Hausa women. This was the case even though age was strongly associated with periodontitis, as has been documented in other studies (Albandar, 2002a). While some researchers argued that the increased risk of periodontitis with ageing is due to altered immune response against oral pathogens, others posited that age-related periodontitis is the result of aggregate effects of tissue destruction that manifest with higher severity in older age cohorts (López *et al*., 2017).

There is limited research on the association between parity and periodontal disease and the results are inconclusive. The mixed results may be due to differences in sample demographics and failure to consider confounders, or that the factors considered are different making study comparison difficult. In addition, there is considerable variation in the ways periodontal disease is measured. Tanzanian women with more than three children experienced significantly more periodontal attachment loss (Scheutz *et al*., 2002). Similarly, Wandera *et al.* (2009) documented a significant association between parity and periodontitis among rural and urban young pregnant Ugandan women. On the contrary, Yas (2012) and Onigbinde *et al*. (2014) found that high parity had no pronounced effect on the periodontal status of pregnant women from Baghdad and Nigeria respectively. Unlike our study, these two studies analysed samples of young women. Yas (2012) excluded women 26 years and above, while

Onigbinde *et al*. (2014) excluded women over 45 years. Thus, it may be difficult to determine whether the cumulative effect of repeated pregnancies is associated with periodontal disease in these women. Pregnancy induced gingivitis/periodontitis is reversible; therefore longitudinal studies are required to most effectively explore the effects of pregnancy and parity on periodontal health.

### 5.5 Socio-economic status, parity and oral health (caries, periodontal disease and tooth loss) in Hausa women

We observed that the caries experience, periodontal health status and tooth loss were not associated with SES. This reflects the homogenous character of our sample where SES differentials are not substantial. The differences were mostly age-related as older Hausa women are much more likely to be involved in work or business enterprises outside the home. In other contexts, socio-economic status has been argued to be a key contributor to women's oral health status and related tooth loss, with individuals of low SES having the poorest oral health (Cunha-Cruz *et al*., 2007; Holst, 2008; Celeste *et al*., 2011).

Pregnancy and maternity are known to modify dental care utilization patterns (Gaffield *et al*., 2001; Timothe *et al*., 2002). In Nigeria, availability and accessibility of oral health care services is poor, thus the reason for untreated caries observed in our sample will eventually contribute to more tooth loss. In addition, there is a general belief that dental health problems are not life threatening and dental care is given low priority relative to other health seeking behaviours (Westaway *et al*., 1999; Varenne *et al*., 2006) There is the need for oral health awareness and education among the Hausa women to promote attitudinal changes and to identify barriers to dental care service.

Although socio-economic status was not related to periodontitis in Hausa women, level of education was strongly associated with periodontal disease. Women with lower educational attainment had the worst periodontal conditions in this study. Education is associated with knowledge, which leads to better oral hygiene practices and translates into good periodontal health. Educational level is generally linked to socio-economic status. Boillot *et al*. (2011), in a systematic review with meta-anaylsis on education as a predictor of chronic periodontitis involving 18 studies, concluded that low level of educational attainment was associated with increased risk of periodontitis.

**5.6 Relationship between nutritional status and oral health (caries, periodontal disease and tooth loss) in Hausa women**

BMI status of Hausa women was not associated with caries experience, periodontal disease or tooth loss. This suggests that age and parity, rather than nutritional status or dietary composition, influence oral health status in Hausa women. The BMI status of the women differed with age, with most overweight/obese women in the upper extreme of age while the reverse was noted for underweight individuals. This pattern is normal for women in most populations. Elsewhere in Nigeria, BMI status was not found to be associated with caries or periodontitis of participants in Benin-City although it was argued to be likely related to gingival bleeding (Sede and Ehizele, 2014).

The association between BMI status and tooth loss is complex. Obesity is associated with periodontal disease, which may ultimately lead to tooth loss. Metabolic changes in obese individuals favour the colonization of *T. forsythia*, a bacterium that promotes periodontal disease. In addition, overweight and obesity are associated with C-reactive protein, a marker of low-grade inflammation that triggers periodontitis (Suresh and Mahendra, 2014). Conversely, impaired oral health status can modify the dietary pattern. Yoshida *et al*. (2014) reported that edentulism is related to underweight as well as obesity in some populations. Further research is required on the link between BMI status and tooth loss.

## 5.7 Tooth loss in the Hausa context

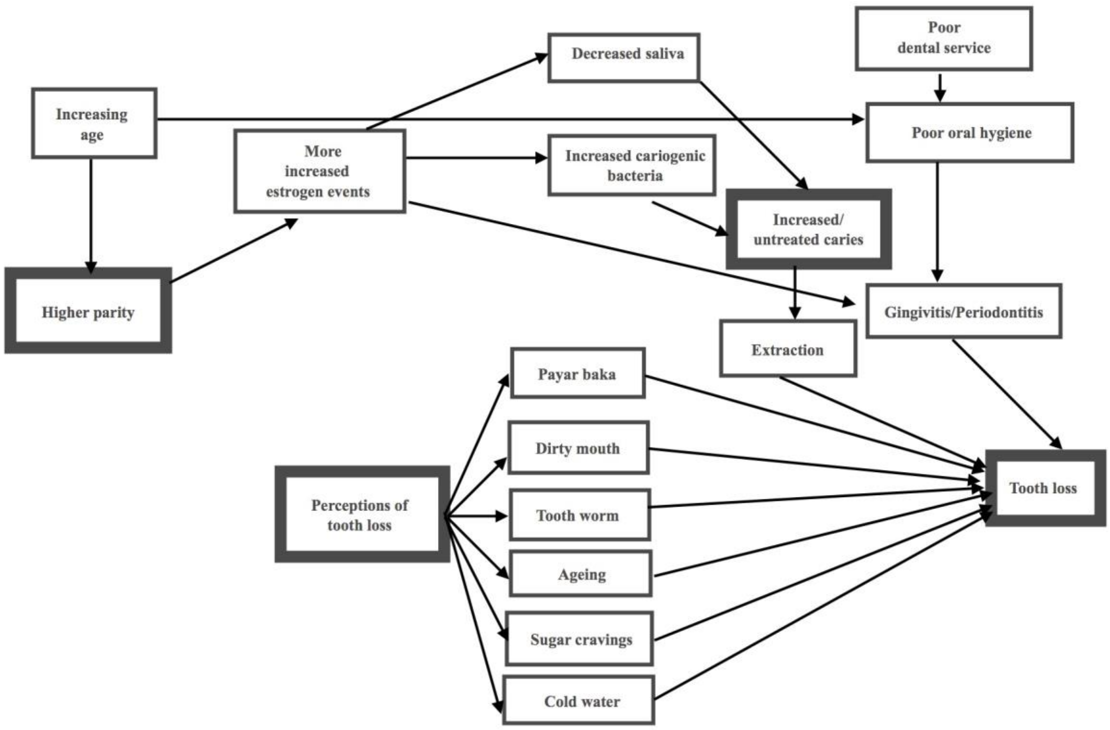


**Figure 5.1 Pathways to tooth loss in high parity Hausa women**

High parity is related to high levels of estrogen over the reproductive years (Lukacs and Largaespada, 2006). Increased estrogen levels are associated with decreased saliva flow and increased cariogenic bacteria, which promotes caries. In addition, increased sex hormones during pregnancy are associated with gingivitis and periodontal disease. These conditions often resolve after childbirth, however it may progress and lead to tooth loss. High parity and pregnancy are documented to influence access to, and utilization of, dental care services. In addition, dental care of pregnant women is often limited to the second trimester; thus dental problems (caries and gingivitis/periodontal disease) may worsen with time such that the teeth require extraction. Increased age, which is directly related to high parity, is also associated with poor oral hygiene with the outcome being gingivitis and periodontal disease and if untreated may lead to tooth loss.

Hausa women perceived various reasons for tooth loss ranging from the traditional *payar baka* (vomiting during labour) and tooth worm concepts to the more current dental practice concepts of dirty mouth (poor oral hygiene), ageing and refined sugar consumption (Figure 5.1).

Based on the significant associations between caries, tooth loss and parity in this study, further research is required to understand the ways parity influences oral health in women. A significant proportion of Hausa women experienced oral health changes due to pregnancy and parity. Thus, reproductive histories are additional predictors of oral health in women and public health interventions aimed at the most vulnerable higher parity women may impact positively on their oral health status.

## 5.8 The effect of Hausa women's maternal oral health on their children's dental caries experience (ECC)

The caries experience in the children was overall of low intensity and maternal caries was not associated with caries experience in their children. This may be due to the generally low caries observed in both mothers and children in our study, making it difficult to detect a relationship. Family factors, most especially maternal transmission of cariogenic bacteria to young children, are thought to play an important role in caries formation. It is suggested that mothers who are caries active are more likely to have children with caries but this remains an area requiring further research and comparable study designs. Studies of American, Turkish and Thai mother-child dyads reported a positive association between mothers' caries status and caries experience in children (Smith *et al*., 2002; Ersin *et al*., 2006; Thitasomakul *et al*., 2009). Smith *et al*. (2002) purposively selected a small American sample of 3-5 year-old children with and without caries. The hospital-based Turkish study included children aged 15 to 35 months and the prevalence of ECC was 9%. The Thai longitudinal study of 9 to 18 month-old children did not report the prevalence of caries at baseline, but they reported a great increase in ECC during the follow up period. Our study was a household survey of children less than 72 months of age and this could account for the observed differences. Interestingly, Kawashita *et al*. (2009) documented no significant association between Japanese maternal caries experience and caries status in a sample with a high child caries prevalence of 35.4%. The study included mothers with 3 year-olds who presented at a health care facility for check-ups.

## 5.9 Limitations

Due to the cross-sectional nature and scope of this study, a cause and effect relationship cannot be deduced between parity and maternal oral health status (caries,

periodontal disease and tooth loss). Matching of women of the same age but different parity groups (low and high) was also not possible because of the distribution of parity and age in our sample. Few older women were nulliparous or of low parity.
A community-based study such as ours has advantages over clinical-based research as it is more representative of the general population, yet it presents other challenges. Selection of a suitable study site entailed a long process and required many levels of permission that constrained our sample size.

Other limitations of our study pertain to the precision of our data relating to periodontal disease. Information on associated risk factors for periodontitis, such as psychosocial stress and family history of periodontitis, were not obtained. Additionally, we did not conduct a full study of dietary intake and nutritional status.
BMI was used as a proxy for nutritional status. This is not without limitations, as it can be an insufficient indicator of energy avaliabiltiy and nutritional status (Jasienska *et al*., 2017).

This study did not directly evaluate whether cumulative maternal nutritional depletion is related to oral health (caries, periodontitis and tooth loss), although demonstration of an association between parity and tooth loss, when controlled for age, may be used to infer the type of depletion attributed to MDS has occurred. Assessment of MDS is very complex and would necessitate evaluation of nutritional status and bone quality over several phases of the life course. Thus a longitudinal study is more appropriate to assess maternal depletion as a cause of tooth loss in women. The low levels of caries and tooth loss in the study population are very interesting findings. Future investigations on the oral health status of men in the Hausa community are required for comparison with the women's oral health taking into account reproductive histories. Additionally our data for the children was necessarily limited to those present in the household during the data collection.

**5.10 Conclusions**

The following general conclusions can be drawn from this study:

1. Parity was related to tooth loss in Hausa women. Higher parity was associated with the loss of more teeth.
2. Parity was positively associated with caries experience in Hausa women.

3. Parity was not associated with periodontal disease levels among Hausa women.
4. The socio-economic status of Hausa women was not related to their oral health status as measured by caries, periodontal disease and tooth loss.
5. The nutritional status of Hausa women, as measured by BMI status, was not associated with their caries experience, periodontal disease or tooth loss.
6. Maternal caries experience was not related to caries experience (ECC) in their children.
7. Hausa women did not perceive parity *per se* as directly associated with tooth loss, yet they viewed childbirth experiences, particularly vomiting, as a cause of tooth loss in reproductively active women. Other pregnancy-related factors they mentioned were sugar cravings, but this dietary behaviour was not verified by the quantitative analysis.

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## Appendix 1

PLOS ONE

RESEARCH ARTICLE

# Is parity a cause of tooth loss? Perceptions of northern Nigerian Hausa women

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## Abstract

### Background

Reproduction affects the general health of women, especially when parity is high. The relationship between parity and oral health is not as clear, although it is a widespread customary belief that pregnancy results in tooth loss. Parity has been associated with tooth loss in some populations, but not in others. It is important to understand the perceptions of women regarding the association between parity and tooth loss as these beliefs may influence health behaviors during the reproductive years.

### Aim

To explore the views of Hausa women regarding the link between parity and tooth loss.

### Methods

Qualitative data were collected through a grounded theory approach with focus group discussions (FGDs) of high and low parity Hausa women (n = 33) in northern Nigeria. Responses were elicited on the causes of tooth loss, effects of tooth loss on women's quality of life, issues of parity and tooth loss, and cultural beliefs about parity and tooth loss. The data were analyzed thematically using ATLAS-ti.

### Results

Respondents associated tooth loss with vomiting during labor, a condition termed 'payar baka'. Poor oral hygiene, excessive consumption of refined carbohydrates, tooth worm, cancer and ageing were also believed to cause tooth loss. The greatest impacts of tooth loss on the lives of the respondents were esthetic and masticatory changes.

### Conclusion

Respondents perceived that parity is indirectly linked to tooth loss, as reflected in their views on the association between vomiting during labor and tooth loss.

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**Competing interests:** The authors have declared that no competing interests exist.

## Introduction

"A tooth for every child" is a common phrase in many societies [1]. Women frequently trace their oral health problems to their reproductive years. A woman looks forward to being a mother with great joy, but could it be at a cost to her oral health? Pregnancy, breastfeeding and childcare are associated with physiological, metabolic and energetic demands. The stresses of repeated pregnancies can lead to permanent changes in health, especially when parity is high [2]. These changes can include negative effects on oral health. It is posited that the cumulative effects of nutritional stress from repeated pregnancies cause calcium depletion from bones and tissues in the oral cavity, with subsequent loss of teeth [3]. The notion of pregnancy draining calcium directly from teeth is often raised, but it has not been substantiated [4–6].

Parity research has focused on the effects of parity on general health, with few studies on oral health. General associations between higher parity and more teeth lost are documented among women of European ancestry [1,7–9]. There are few data for African women or women in rural settings. No study has focused on how women view the role of parity in tooth loss. Consequently, this study addresses a gap in the literature concerning information on the perceptions of African women regarding parity and tooth loss.

### Tooth loss

In the past, tooth loss was considered part of normal aging and unavoidable [10]. Presently, the reverse is the case, particularly in areas where dental care is available. The loss of one or more teeth can affect an individual's quality of life [11]. Aside from obvious changes in appearance and mastication, tooth loss can affect self-esteem, speech and social interaction. Koyama *et al.* [12] found that higher levels of social engagement were associated with less tooth loss in older Japanese individuals.

Qualitative and quantitative studies on individuals with complete or partial tooth loss document serious negative emotional consequences [13–15]. Completely edentulous patients reported bereavement, loss of self-confidence, concerns about appearance and self-image, tooth loss as a taboo subject that could not be discussed with other people, and keeping tooth loss secret [14]. Partially dentate patients described tooth loss as a sense of being incomplete and having lost a part of their body [13].

There are various causes of tooth loss. The principal contributors are caries and periodontal disease; others include trauma, orthodontic treatment, tooth impaction, cystic lesions and neoplasms [10,16]. Cultural identity markers also incorporate evulsion of the highly visible incisors and canines [17]. Globally, caries is the principal reason for tooth loss along with extraction following periodontal disease. This characterizes countries with extensive dental care facilities as well as developing countries [18–21].

Age, gender, socio-economic status, level of education and utilization of oral health services are associated with differing levels of tooth loss [12,22,23]. Individuals with low socio-economic status overwhelmingly have the worst oral health [24,25], yet lower level of literacy and poor attitudes towards dental check-ups also are associated with tooth loss [26,27].

Gender-based dietary differences, eating patterns, resource availability and cultural attitudes towards health, pain and dentistry underlie male-female differences in tooth loss [28,29]. Tooth loss frequency varies by sex in most societies and appears to be context dependent. Some studies describe sex as a significant predictor of tooth loss with a tendency towards higher prevalences in females [28,30–33], while others report higher levels in males [34,35].

The observed male-female differences in tooth loss are usually attributed to changes in female sex hormones during pregnancy, with a logical inference that parity is related to tooth loss. Two different Swedish studies [7,8] observed that parity had an impact on tooth loss.

High parity negatively correlated with the number of remaining teeth. Conversely, Scheutz *et al.* [36] documented no link between parity and tooth loss in Tanzanian women, but they observed a relationship between parity and the principal cause of tooth loss—periodontal disease.

Thus, the association between parity and tooth loss remains unclear. There are complex confounding factors that are frequently not considered (including age, age at first birth, duration of birth intervals, breastfeeding duration, pre-existing nutritional status and food uncertainty) and this makes it difficult to draw conclusions regarding parity effects. It is also necessary to investigate the views of women on this issue to gain insights into their understanding and perception of parity and tooth loss. This is particularly critical in contexts with significantly differential parity and/or high parity. The perceptions of women are important as these may shape their behavior and attitudes towards oral health care. Women may resign themselves to a fate where pregnancy is expected to cause tooth loss, instead of seeking preventive care and dental treatment to maintain their oral health.

Hausa women of northern Nigeria were studied as part of a larger project on maternal and child oral health in a high parity population. Previously, the prevalence of caries experience and tooth loss in women from the region was found to be high. This was attributed to high consumption of sugars, low socio-economic status and poor utilization of oral health services [37]. However, the oral health conditions of the women may be related to their high parity. According to the latest available statistics, Nigeria has a high total fertility rate of 5.7 children per woman. In the northwest zone of the country where the Hausa live, it is 7.3 children [38]. This is ascribed to very early age at marriage, high levels of teenage childbearing, the male dominated social hierarchy, polygyny and low use of modern contraceptives [38,39].

## Methods

### Study design

A grounded theory approach, involving in-depth focus group discussions (FGDs) of high and low parity Hausa women in northern Nigeria, was implemented. This approach is suitable for obtaining data on married women's views regarding parity and tooth loss. A repetitive method of data collection and analysis was employed to develop a theoretical explanation of perceptions grounded in the data collected from the discussions with Hausa women.

### Sample population

The sample population was selected through a household survey in the Kumbotso Local Government Area (LGA) of Kano State, Nigeria using a multi-stage random sampling technique. Kano State is located in the northwest zone of Nigeria and has a population of 9.4 million [40]. Kumbotso LGA has its headquarters in the town of Kumbotso. The population is 295,979 people who live in an area of 158 $km^2$. The LGA consists of 11 administrative wards. According to the 2006 census, 66,010 women aged 15–65 years reside in Kumbotso LGA. Six wards were randomly selected from the LGA. Within each ward, two communities were randomly selected and all households in each community were approached.

### Group composition

A purposive selection [41] of women from different age cohorts and parity levels was identified from the participants in a general study on maternal and child oral health in Kano. The sample consisted of 33 women aged 19–66 years with the size determination based on the theoretical saturation concept of Grounded Theory [42]. Women of all parity levels were included.

Participants were grouped into three age cohorts (19–30 years, 31–45 years and 46–66 years) and each group consisted of an average of five women.

### Data collection method

Trained bilingual Hausa and English-speaking married women with previous experience in qualitative interviewing, along with the principal investigator, conducted the FGDs. The use of local Muslim Hausa women as field workers helped facilitate access to women in seclusion, promoted openness among the women during the FGDs, and minimized the potential objections and suspicions of participant's husbands. The local field workers were not assigned to groups in their own areas. Two FGD sessions were conducted per age cohort, for a total of six gatherings. Sessions were conducted in a quiet meeting room, and the discussions were moderated with the use of an interview guide that was prepared before the sessions.

The FGDs obtained responses to queries on the following topics: causes of tooth loss, effects of tooth loss on the quality of women's lives, issues regarding parity and tooth loss, and cultural beliefs on parity and tooth loss.

All interviews were taped, transcribed, and translated verbatim from Hausa into English. Two Hausa language teachers at Bayero University, Kano, and two Hausa-speaking dentists (also from Kano State and not involved in the study) supervised the transcription and translation.

### Ethical considerations

Ethical clearance for the study was obtained from the Ethics and Research Committee of Obafemi Awolowo University, Ile-Ife, Osun State, Nigeria (IPHOAU/12/717) and from the Human Research Ethics Committee of the University of the Witwatersrand, Johannesburg (M170343). A male local assistant who could speak Hausa fluently was employed to facilitate links with village leaders and husbands. Permission was obtained from local village leaders to conduct the study and informed consent was obtained from the husbands of married women living with their husbands. Written informed consent was obtained from each participant. The consent form was translated into Hausa and read to the participants who were not literate. Women who were not literate and were willing to participate in the study thumb printed on the consent form.

### Data analysis and theory building using the grounded theory approach

**Coding and theorizing.** Using the grounded theory approach, open, focused and axial coding was employed [42–47]. Throughout the analysis, memoing was done to facilitate the hypothesis formulation [48]. Two major theoretical categories were generated around the assumptions and beliefs attached to childbearing and tooth loss in women: the causes of tooth loss and the effects of tooth loss on women of childbearing age.

Network diagrams were drawn using the network view function of ATLAS.ti to show the relationships between categories and to display the models to explore the data and visualize the ideas and findings [49]. Illustrative direct quotations were drawn from the text to highlight key findings.

## Results

The mean age of the participants was 40.82 ± 14.99 years. More than half (54.5%) of the respondents had no formal education. Eighteen (54.5%) had five or more children. The mean parity was 4.48 ± 3.00. There was a significant difference between the mean parity levels by age

**Table 1. Socio-demographic characteristics of participants.**

| Characteristics | Total N = 33 |
|---|---|
| **Age (years)** | |
| 19–30 | 11 (33.3%) |
| 31–45 | 12 (36.4%) |
| 46–66 | 10 (30.3%) |
| **Level of education** | |
| Koranic only | 18 (54.5%) |
| Primary (partial or completed) | 5 (15.2%) |
| Secondary (partial or completed) | 10 (30.3%) |
| **Number of children (living)** | |
| $\leq 4$ | 15 (45.5%) |
| 5–8 | 14 (42.4%) |
| $> 8$ | 4 (12.1%) |
| **Mean parity by age cohorts** | |
| 19–30 | $2.18 \pm 1.60$ |
| 31–45 | $6.25 \pm 2.22$ |
| 46–66 | $4.90 \pm 3.51$ |
| | $p = 0.002$ |
| Mean age (years) | $40.82 \pm 14.99$ |
| Mean parity | $4.48 \pm 3.00$ |
| **Occupation** | |
| Traders | 26 (78.8%) |
| Housewives | 7 (21.2%) |

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group ($p = 0.002$). The majority of the women (78.8%) were small-scale informal traders in the market and the remainder (21.2%) were housewives (Table 1).

## Key findings and interpretation

The findings from this study reflect the beliefs and thoughts of Hausa women of child bearing and post childbearing ages. The themes included "Perception on the relationship between tooth loss and childbearing", "Beliefs about tooth loss", "Causes of tooth loss", and "Effects of tooth loss on women".

The network diagram [Fig 1] shows the perceived causes of tooth loss among Hausa women of childbearing and post-childbearing age. These etiologies include dirty mouth, vomiting during labor, excessive sugary diet, aging, food impaction, tooth worm infection and hole in the tooth, drinking cold water, road traffic accidents, other accidents, fights, extractions or loss due to poor tissue support and cancer. These causes are further described below.

## Array of reported causes of tooth loss

**Poor oral hygiene.** Respondents identified poor oral hygiene as a major cause of tooth loss among women. Because most women do not practice good dental care, they have tooth decay and tooth loss. Kolanut, a mild stimulant chewed to restore vitality and reduce hunger pangs, results in staining of teeth and was associated with poor oral hygiene.

> *. . ..because of dirty mouth and kolanut chewing. Kolanut turn the colour of the teeth bad and make them dirty*

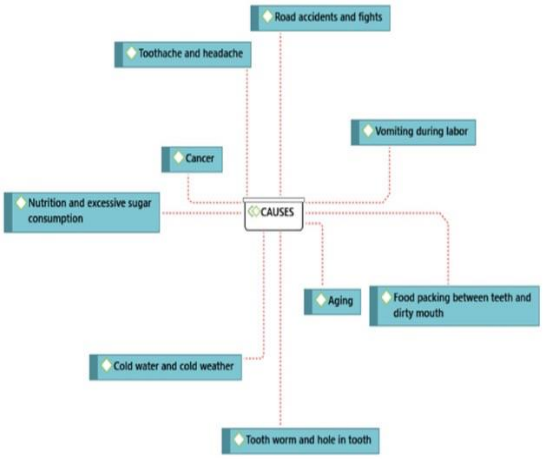


**Fig 1. Causes of tooth loss during childbirth.**

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*. . ...**R3, REC 013, Hausa community***

*. . .. Some women are unable to take care of their teeth because they do not care about the mouth*

*. . ...**R2, REC 010, Hausa community***

*. . ...lack of brushing the teeth will make them fall out.*

*. . ...**R1, REC 012, Hausa community***

*. . .. . . . ..poor personal cleaning make the mouth to smell after sometime the teeth will be shaking and fall out.*

*. . ...**R5, REC 015, Hausa community***

**Food impaction, tooth worm infection and caries.** It was also discovered during the discussions that food impaction, inadequate dental care during pregnancy, and worms infesting the oral cavity lead to tooth loss. Worms create the holes seen in teeth, cause caries, make the teeth weak and eventually they are lost. Below are responses to support these points:

*. . ..meat impaction between teeth.*

*. . ..Hole made by worms*

*. . ...**R3&R5, REC 015, Hausa community***

*. . .Tooth worms eat the tooth and make a hole in it. This cause tooth pain*

*. . .Tooth worms make holes in teeth and cause pain*

*. . . I hear traditional medicine people say that tooth worm make holes in teeth and later gives pain and the tooth will be removed*

*. . .. . .dirty mouth have worms that damage the teeth*

***. . ...R1, R2, R3 & R4, REC 011, Hausa community***

**Aging.** Discussants stated that women age faster than men due to childbearing and domestic chores. These cause them to lose their teeth earlier than men.

*. . ...Women become old earlier than men and it is because of childbearing. Because of this women lose more teeth than men*

*. . ...My friend who left the city for the village now has missing teeth maybe because she works more and she is not able to take care of her body. She is going to become old earlier than the people in the city.*

***. . ...R2 & R3 REC 012, Hausa community***

*. . ...as you grow old the teeth are no more strong, they are weak and will fall out one by one*

***. . .,R6, REC 011, Hausa community***

**Nutrition and excessive sugar consumption.** Furthermore, it was mentioned during the course of the discussion that pregnant women enjoy eating excessive sugar and sugary foods. This leads to weak teeth, causing toothache and easy loss of the teeth. It was unanimously agreed that women mostly lose more teeth than men because of excessive sugar consumption.

*. . ...maybe she chew gums which contains sugar and can cause tooth hole and tooth loss.*

***. . ...R2, REC 012, Hausa community***

*. . ..consumption of sugar coating food make holes in teeth*

*. . ...consumption of honey, it is sweet and can cause holes in teeth*

***. . ...R2& R6, REC 013, Hausa community***

*. . ...girls like to eat sweets and chew gum, these make the teeth go bad. They cause holes and pain and the teeth are removed later*

***. . ...R1, REC 011, Hausa community***

**Cancer.** Respondents suggested that women of childbearing age could lose their tooth if they have cancer of the mouth.

*. . ..Maybe the women that lost teeth have cancer*

***. . ... R6, REC 010, Hausa community***

*. . .. Cancer, big or small makes the teeth to be shaking and fall after some time*

. . .. . .. ***R1, REC 014, Hausa community***

**Other causes of tooth loss.** Respondents offered that using the teeth to open bottled drinks could cause pain/trauma leading to loss of teeth. In addition, it was mentioned that teeth can be lost through fights or road traffic accidents and can also fall off by themselves (perhaps due to periodontal disease) or through extraction.

*. . ... using teeth to open drink/ Coca-Cola crown tops or biting something hard. The tooth can break or fall out*

*. . .. . . "Okada" (motorcycle) or car accidents can make teeth fall out if you hit you mouth on the"Okada"or ground*

. . ...***R2, REC 015, Hausa community***

*. . .. My tooth was removed because of pain. There was a hole in it.*

*. . ..Yes, my tooth came out on it own. It was shaking before it fell off*

. . ..***R2& R3, REC 010, Hausa community***

*. . .punch or slap on the face from fights between two people can make teeth fall off*

. . .,***R4, REC 013, Hausa community***

Furthermore, it was mentioned that ingestion of cold water and cold weather could lead to tooth loss.

*. . .. . . drinking cold water and cold weather. . . . . .*

. . ...***R6, REC 011, Hausa community***

**Effects of losing teeth.** Discussants described the effects of tooth loss in women of child-bearing age as including esthetic decline, loss of self-esteem, eating and chewing difficulties, and financial burden.

Respondents said that tooth loss affects their self-esteem. Sometimes they lose their joy and are unable to speak in public and smile because of the shame of their lost tooth.

*Very painful associated with missing of joy because you cannot talk or laugh like you want to in public*

. . ...***R2, REC 014, Hausa community***

*Esthetic problem [I can't laugh well because the gap (edentulous space) will show]*

. . ...***R3, REC 010, Hausa community***

*R3: Esthetic/ loss of self-esteem [I don't like to laugh or talk in public so that people will not laugh at me]*

*R5: It affects the beauty [when you lose your front teeth you don't look beautiful again]*

*R6: Unable to smile*

*. . ...**R3, R5 &R6 REC 012, Hausa community***

In addition, tooth loss makes eating and chewing difficult for them. It was noted during the course of discussion that tooth loss causes pain and discomfort during mastication.

*. . . difficulty in eating/ chewing—I am unable to chew meat or maize, I miss out on them*

*. . .. . ..anytime I try to chew meat or maize, it is discomforting when the food is on the gum at the back where there are no teeth. I don't enjoy it.*

*. . ...because it is front teeth I don't have difficulty in chewing but I don't feel pretty like I was when the teeth were there.*

*. . ...**R3&R5 REC 011, Hausa community***

Finally, respondents complained about the financial burden to replace their teeth when they lose them. They mentioned that it is expensive to replace missing teeth.

. . ...unable to chew and to replace with artificial teeth you have to pay money [Financial burden]

*. . ...**R1, REC 011, Hausa community***

**Perceptions and beliefs on the relationship between parity and tooth loss.** Respondents were unanimous in their belief that there is a relationship between tooth loss and childbearing [Fig 2].

Respondents said that during the course of labor, women vomit, which makes their teeth weak and results in tooth loss. Excerpts from interactions with the respondents include:

*. . ...Yes. I think because I know a woman with five children and she lost some teeth.*

*. . ...**R2, REC 015, Hausa community***

*. . .. . .Vomiting during labor in female, which will make the teeth weak and will not last. Yes, I am having vomiting during labor and only one tooth lost after menopause.*

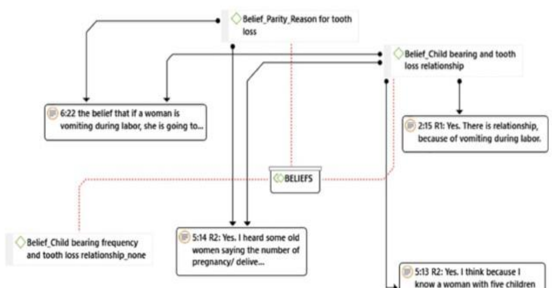


**Fig 2. Thematic beliefs of women on the relationship between parity and tooth loss.**

https://doi.org/10.1371/journal.pone.0226158.g002

. . ...**R2, REC 010, Hausa community**

. . ..*Yes, I do vomit during labor and I lost my tooth [two teeth]*

. . ...**R3, REC 012, Hausa community**

. . .*We heard that when women are having vomiting during labor their teeth are not going to last.*

. . ...**R1, REC 013, Hausa community**

.. *I vomited during labor but did not lose a tooth but I am afraid that I will lose one soon or later*

. . .. . .**R4, REC 014, Hausa community**

. . .. *I know that pregnancy will cause lose of hair, nail, tooth. It also causes pain in tooth. When I was pregnant I lost my hair but not my tooth or nail.*

. . .. . .**R5, REC 011, Hausa community**

. . .. . ..*the number of pregnancy that a woman has is the number of teeth she will lose.*

. . .. . .**R6, REC 016, Hausa community**

. . .. . ... *I lost a tooth because I vomited when I was in labor*

. . .,**R7, REC 015, Hausa community**

During the course of the discussion, respondent gave a local phrase ***"payar baka"*** for vomiting during labor. Quotes to buttress this are:

. . .. . . *Vomiting during labor [payar baka]*

. . ...**R1, REC 010, Hausa community**

. . ... I vomited when I was going to have my last child and my tooth fell off

. . ..**R3, REC 013, Hausa community**

However, some respondents believed there is no relationship between tooth loss and child bearing. Excerpts from interaction with the respondents are shown below:

. . ... *(Q: Any relationship between parity and tooth loss?). It's not due to pregnancy. It's due to guava seed impaction between the teeth but that happened during pregnancy, I have 12 children without losing any tooth.*

. . ..**R1, REC 012, Hausa community**

. . .. . .. *I lost some teeth before I marry so it cannot be pregnancy that cause it since I was not pregnant before I marry*

. . ..**R3, REC 014, Hausa community**

*. . .. . . No (Q7: Is there any relationship between the number of children women have and the number of teeth lost?)*

*. . ... No [unanimously]*

*. . ...**R1&6, REC 011, Hausa community***

Some respondents stated that tooth loss is not associated with pregnancy or childbirth. It emerged that this belief was based on the observations that young girls can also have tooth decay that leads to tooth loss. Excerpts from interactions with the respondents are provided below:

*. . .. . .some women also have holes in teeth associated with tooth loss but not really associated with childbearing. Because even a very young girl can have holes in teeth associated tooth lost.*

*. . .. . ..I lost some teeth before I marry or even have children. It cannot be pregnancy maybe the sweets and chewing gum I took when I was young.*

*. . ...**R6 & R7, REC 010, Hausa community***

## Discussion

To the best of our knowledge, this is the first qualitative study to explore the perceptions of women on parity and tooth loss. Our research provides an in-depth understanding of women's perceptions regarding the issue in a society where high parity is the norm. All the discussions were conducted in the participant's local language (Hausa) and environment. This was to reduce misinterpretation, possible bias and false response [50]. The separation of participants into different age groups allowed for diverse experiences and perceptions within the cultural group to be expressed.

Generally, the women in this study did not perceive that the number of children is directly associated with tooth loss. Pregnancy was indirectly related to tooth loss via the belief that a woman is prone to lose a tooth or at risk of losing one in future if she vomits during childbirth—the condition known as "payar baka". Those who vomited during childbirth but did not lose a tooth were afraid that they would lose a tooth or more teeth later in life. The participants could not explain the basis for the link between vomiting during labor and tooth loss. Women could be conflating forceful vomiting with expelling of teeth that are lost due to weakened gingival and periodontal tissues.

Vomiting, the forceful expulsion of gastrointestinal content through the mouth, is common during labor. It is often a result of anxiety and nervousness about the labor process. In addition, severe labor pains and contractions can induce vomiting. A literature search on vomiting during labor and tooth loss did not yield any further information. It is possible that the belief of the Hausa women is specific to their population.

The participants in this study offered various causes for tooth loss. One of these was "dirty mouth". Dirty mouth, often the result of inadequate or no tooth brushing, is characterized by accumulation of plaque and calculus deposits. These deposits harbor microorganisms that produce toxins, which are harmful to the supporting structures of the teeth. This situation leads to gingivitis, and if untreated may progress to periodontitis and possibly tooth loss. Pregnancy is associated with gingivitis and periodontitis, with progression of these oral conditions during the pregnancy [51]. In addition, women with previous pregnancies have higher gingival index scores and periodontal probing depths than those pregnant for the first time [52–54]. It is therefore likely that pregnancy has an indirect effect on the supporting structures of the teeth that may affect tooth loss. However, the women in the focus groups did not mention the acute symptoms associated with pregnancy gingivitis.

Worm infection is another factor our respondents believed to cause tooth loss. Tooth worm was a widely held concept historically. There are oral and written accounts of tooth worms and tooth decay in antiquity [55]. The worms were believed to burrow through the teeth to cause decay and pain. Similarly, tooth worms were linked to periodontal disease. In Africa, guinea worms from infected drinking water were considered to be a cause of tooth decay because the worms breed in cool water settings such as deep wells [56]. Presently, deep cool wells serve as major sources of drinking water in developing countries but not in developed countries [57]. Consumption of rotten, maggoty cheese was another suggested source of tooth decay [58]. The Sudanese believed in the concept of tooth worms ('*sosa*') from infested foods as a cause of tooth decay [59]. The tooth worm theory of tooth decay was first discredited by Fauchard (1678–1761) and further disproved following the Age of Enlightenment [60]. For the Hausa people, the tooth worm concept may persist because worm infestation is a reality of their daily lives. Guinea worms, now approaching eradication, were until recently endemic in regions of northern Nigeria [61]. Their breeding in cold water may tie into Hausa women's belief that drinking cold water is a cause of tooth loss.

Some of the respondents in our study perceived that sugary foods, including chewing gums, are associated with tooth loss from carious decay. The origin of this belief is most likely a reflection of Hausa women's exposure to modern dentistry and health awareness. Even the packaging of common products, such as chewing gums, frequently includes messages about the effects of sugar. The Hausa women in our study related sugar consumption to pregnancy cravings. This may be culturally specific or dependent on local food resources, as pregnancy cravings for non-sugary foods in Africa are known to include clay and soils [62,63]. While most studies document higher caries rates in women than men [28,30–33], differential consumption of sweet foods has not been directly implicated as the cariogenic agent. Walker and Hewlett [28] attributed the heightened caries experience of women to their involvement in food processing and preparation, and with snacking patterns that enhance the cariogenic oral environment. Pregnancy and parity are related to caries experience in some groups, with women of high parity having more caries in studies of Thai and US women [64,65]. However, there was no link between parity and caries in women from Tanzania and black South African women [4,36]. This is an area requiring further research with more detailed examination of dietary variability and oral health practices amongst women of high parity.

The participants in this study believed that women age faster than men due to the stress of reproduction and household chores. Consequently, women lose more teeth than men. The natural process of ageing is universally linked with tooth loss. Periodontal disease, caries and tooth wear become worse and predispose an individual to tooth loss as they age. Maintaining good oral hygiene can be difficult in old age due to poor mobility or the inability to carry out fine movements for effective plaque removal [66]. In addition, ageing comes with health challenges such as diabetes, cardiovascular disease and the use of medications that can cause gingival swelling and xerostomia (dry mouth) [66]. These health challenges, if not adequately managed, further deteriorate the oral health leading to tooth loss. High parity women are prime candidates for oral health complications. They are at greater risk of diabetes and cardiovascular disease [2]; a systematic review concluded that adults with diabetes have an increased risk of onset and progression of periodontal disease [67]. At present, it is unknown if the advancement of aging described by Hausa women refers to their general strength and energy or if it includes some of these other age-related issues.

Tooth loss impacts greatly on the quality of life, and the participants in this study perceived that the loss of one or more teeth affects mastication, their appearance, their sense of well-being and their financial status. Functional and esthetic impairments are widely reported in the literature as major effects of tooth loss on individual quality of life [11,14,68]. As tooth loss is associated with ageing, individuals may perceive that they are old following the loss of a tooth. Affordability of dental care may be a challenge, especially in developing countries. The participants in this study perceived that replacement of a missing tooth was expensive. This may further reduce their quality of life because their hope of tooth replacement is low.

Hausa women's views on tooth loss illustrate that their knowledge base incorporates traditional beliefs (*payar baka*, tooth worm, sugar cravings), cultural notions of aging and attractiveness, and Western dental concepts regarding oral hygiene. These findings have clear implications for future health initiatives, which need to address the complexity of existing beliefs when working to change oral health behaviors.

The results of this study cannot be generalized because they represent the perspectives of a specific group of participants. It is possible that a different group of participants may have different views. However, this limitation was taken into consideration by involving women of different age groups and parity levels.

## Conclusion

The study participants offered various reasons for tooth loss, including poor oral hygiene, vomiting during childbirth, tooth worm and ageing. The respondents perceived gender inequality in tooth loss, with a tendency towards more loss in females. Masticatory and esthetic impairments were the most perceived negative effects of tooth loss on the quality of life. Generally, the women in this study do not perceive parity per se as directly associated with tooth loss. They associated childbirth experiences, particularly vomiting, as the cause of tooth loss. The fact that the condition was identified with a specific term in the Hausa language ('*payar baka*') illustrates that it describes a common occurrence with relevance to women's health knowledge and oral health behaviors.

## Supporting information

**S1 Data. Bio data.**
(XLSX)

**S2 Data. Questionnaire data.**
(DOC)

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## Author Contributions

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**Appendix 2**

**Data collection form for mothers**

Section A

1. Serial number:

2. Sex: Female

3. Age: 4. Date of birth

5. Ethnic group:

6. Type of marriage: (a) Monogamous (b) Polygamous (Number of wives……..)

7. (a) Age at first child: (b) Age at last child:

8. Number of pregnancies:

9. (a) Number of children: (b) Average age between each child:

10. Duration of breastfeeding per child:

11. (a) Occupation ………………(b) Occupation (husband)…………………………

12. Level of education (a) None (b) Primary (c) Secondary (d) Koranic (e) Tertiary

Section B (Tick the appropriate response)
(Questions 13-24 address oral health behaviour while 25-35 address oral health knowledge)

13. Is there any special food you eat a lot during pregnancy? (a) Yes (b) No

14. If yes to question 12, what is/are the special food(s)?

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15. How often do you eat sugar containing snacks or drinks between your main meals?
(a) Three or more times a day (b) Twice a day (c) Once a day (d) Occasionally not everyday (e) Rarely or never eat between meals (e) No response

16. How often do you usually brush your teeth?

(a) Irregularly or never (b) Once a week (c) Two to three times a week (d) Once a day (e) Twice a day (f) more than twice a day (f) No response.

17. When do you clean your teeth?
   (a) Morning before breakfast (b) Morning after breakfast (c) Afternoon before lunch (d) Afternoon after lunch (e) Evening before supper (f) Evening after supper (g) No regular time interval (h) No response.

18. What do you use to clean your teeth?
   (a) Tooth brush and toothpaste (b) Chewing stick (c) Hand and water (d) Hand and salt (e) Cotton wool and salt (f) Others (specify)…………………..

19. Do you use toothpaste to clean your teeth? (a) Yes (b) No

20. If yes to question 19, what is the name of your toothpaste ……………..

21. (a) Toothpaste contains fluoride (b) Toothpaste does not contain fluoride (to be answered) by the PI

22. How often do you use fluoride-containing toothpaste?
   (a) Always (b) Sometimes (c) Rarely (d) Never

23. When you have problems with your teeth where do you go …………

24. When last did you visit the dentist?
   (a) Last 6 months (b) more than 6 months to 1 year ago (c) 1 to 2 years ago (d) 2 to 5 years ago (e) More than 5 years ago (f) Never (g) No response

25. Do you remember when you lost the first tooth? (a) Before you had your first child (b) During childbearing period (c) After you had your last child (d) I can't remember.

26. Do you remember when you lost the last tooth? (a) Before you had your first child (b) During childbearing period (c) After you had your last child (d) I can't remember

27. Have you removed a tooth before? (a) Yes (b) No

28. If yes to question 23, where was the tooth removed?
   (a) Dental clinic (b) I fell off by itself (c) It broke into pieces (d) Others (specify)………….

Section C

29 (a) Weight --------------- (Kg) (b) Height ----------------- (m)

(c) BMI score ------------ $Kg/m^2$

Section D

30.Teeth present: (Put X on missing teeth )

| Upper Right | | | | | | | | Upper Left | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 18 | 17 | 16 | 15 | 14 | 13 | 12 | 11 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 |
| 48 | 47 | 46 | 45 | 44 | 43 | 42 | 41 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 |
| Lower Right | | | | | | | | Lower Left | | | | | | | |

31. Dental caries status using DMFT: (Put D on Decayed, M on missing teeth due to caries and F on filled teeth.)

| Upper Right | | | | | | | | Upper Left | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 18 | 17 | 16 | 15 | 14 | 13 | 12 | 11 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 |
| 48 | 47 | 46 | 45 | 44 | 43 | 42 | 41 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 |
| Lower Right | | | | | | | | Lower Left | | | | | | | |

32. Oral hygiene status.

a) Good (b) fair (c) poor

33. Periodontal attachment loss

| **Tooth type** | **Buccal** | **Lingual** |
|---|---|---|
| 11 | | |
| 12 | | |
| 13 | | |
| 14 | | |
| 15 | | |
| 16 | | |
| 17 | | |
| 18 | | |
| 21 | | |
| 22 | | |
| 23 | | |
| 24 | | |
| 25 | | |
| 26 | | |
| 27 | | |
| 28 | | |

| **Tooth type** | **Buccal** | **Lingual** |
|---|---|---|
| 31 | | |
| 32 | | |
| 33 | | |
| 34 | | |
| 35 | | |
| 36 | | |
| 37 | | |
| 38 | | |
| 41 | | |
| 42 | | |
| 43 | | |
| 44 | | |
| 45 | | |
| 46 | | |
| 47 | | |
| 48 | | |

**Appendix 3**

**Data collection form for children**

Section F

1. Serial number:

2. Sex:

3. Age: 4. Date of birth……………..

4. Ethnic group:

5. Type of family: (a) Monogamous (b) Polygamous

6. Number of Siblings:

7. Occupation of Father……………………………………….

8. Occupation of Mother

9. Level of education (a) None (b) Primary (c) Secondary (d) Koranic (e) Tertiary

Section G (Tick the appropriate response)
(Questions 11-18 address oral health behaviour)

10. What pattern of breastfeeding did you do for this child? (This question is for the mother)
    (a) Exclusive breastfeeding (b) Almost exclusive breastfeeding (c) Partial breastfeeding

11. Did you carry out a night breastfeeding practice for this child? (This question is for the mother)
    (a) Yes (b) No

12. How often do you eat sugar containing snacks or drinks between your main meals?
    (a) Three or more times a day (b) Twice a day (c) Once a day (d) Occasionally not everyday (e) Rarely or never eat between meals (e) No response

13. How often do you usually brush your teeth?
    (a) Irregularly or never (b) Once a week (c) Two to three times a week (d) Once a day (e) Twice a day (f) more than twice a day (f) No response.

14. When do you brush your teeth?
    (a) Morning before breakfast (b) Morning after breakfast (c) Afternoon before lunch (d) Afternoon after lunch (e) Evening before supper (f) Evening after supper (g) No regular time interval (h) No response.

15. What do you use to brush your teeth?
(a) Tooth brush (b) Chewing stick (c) Salt (d) Cotton wool (e) Cloth (f) Charcoal (g) Ground glass (h) Others.

16. How often do you use fluoride-containing toothpaste?
(a) Always (b) Quite often (c) Seldom (d) Not at all (e) No response

17. When last did you visit the dentist?
(a) Last 6 months (b) more than 6 months to 1 year ago (c) 1 to 2 years ago (d) 2 to 5 years ago (e) More than 5 years ago (f) Never (g) No response

Section H

18 (a) Weight ………… (Kg)    (b) Height ---------- (m)

(c) BMI ---------Kg/m$^2$

Section I

19. Teeth present: (Put X on missing teeth )

Permanent

Upper Right / Upper Left

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 18 | 17 | 16 | 15 | 14 | 13 | 12 | 11 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 |
| 48 | 47 | 46 | 45 | 44 | 43 | 42 | 41 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 |

Lower Right / Lower Left

Decidous

Upper Right / Upper Left

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 55 | 54 | 53 | 52 | 51 | 61 | 62 | 63 | 64 | 65 |
| 85 | 84 | 83 | 82 | 81 | 71 | 72 | 73 | 74 | 75 |

Lower Right / Lower Left

20. Dental caries status using DMFT: (Put D on Decayed, M on missing teeth due to caries and F on filled teeth. )

Upper Right / Upper Left

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 18 | 17 | 16 | 15 | 14 | 13 | 12 | 11 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 |
| 48 | 47 | 46 | 45 | 44 | 43 | 42 | 41 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 |

Lower Right / Lower Left

21. Dental caries status using dmft

| | Upper Right | | | | | Upper Left | | | |
|---|---|---|---|---|---|---|---|---|---|
| 55 | 54 | 53 | 52 | 51 | 61 | 62 | 63 | 64 | 65 |
| 85 | 84 | 83 | 82 | 81 | 71 | 72 | 73 | 74 | 75 |
| | Lower Right | | | | | Lower Left | | | |

22. Oral hygiene status.
a) Good (b) fair (c) poor

## Appendix 4

### Focus Group Discussion Guide

1. What do you understand by the word Parity in relation to toothloss in women? Probe
2. Is toothloss common among women of childbearing age due to parity in this community?
3. What do you call this condition in this community? Is there a name given to it?
4. In your own view, what are the causes of tooth-loss among women of delivery age in this community? Why? Probe for Nutrition, oral hygiene and socio economic status.
5. Do you think/belief parity (number of children given birth to) has anything to do with toothloss in women in your community? Why?
6. If so, can you tell us a story of your experience?
7. How do you manage this condition?
8. What do you think can be done to avert and improve this condition?

**Appendix 5**

HEALTH RESEARCH ETHIC COMMITTEE (HREC)
INSTITUTE OF PUBLIC HEALTH
OBAFEMI AWOLOWO UNIVERSITY, ILE-IFE, NIGERIA.

Institute of Public Health

**Our Ref:** ~~HREC NO: I~~PHOAU/12/717

**Your Ref:** ____________

**Date:** Dec. 22nd, 2016

**Notice of Full Approval after Full Committee Review**

**MATERNAL AND CHILD ORAL HEALTH: INVESTIGATION OF THE EFFECT OF PARITY AND SOCIO-BEHAVIOURAL FACTORS ON THE ORAL HEALTH OF MOTHERS AND CHILDREN**

Health Research Ethics Committee assigned number: IPHOAU/12/717

Applicant's Name: OZIEGBE Elizabeth Obhioneh

Applicant's Address: Dept. of Child Dental Health, OAU, Ile-Ife.

Date of receipt of valid application: Oct. 18th, 2016

Date of meeting when final determination of research was made: Nov. 28, 2016

This is to inform you that the research described in the submitted protocol (HREC No: IPHOAU/12/717), the consent forms and other participant information materials have been reviewed and *given full approval by the Health Research Ethics Committee.* This approval dates from Nov. 28th, 2016 to Nov. 27th, 2017. If there is delay in starting the research, please inform the HREC so that the dates of approval can be adjusted accordingly. Note that no participant accrual or activity related to this research may be conducted outside of these dates. *All informed consent forms used in this study must carry the HREC assigned number and duration of HREC approval of the study.* In multiyear research, endeavor to submit your annual report to the HREC early in order to obtain renewal of your approval to avoid disruption of your research.

*The National Code for Health Research Ethics requires you to comply with all institutional guidelines, rules and regulations and with the tenets of the Code including ensuring that all adverse events are reported promptly to the HREC. No changes are permitted in the research without prior approval by the HREC except in circumstances outlined in the Code. The HREC reserves the right to conduct compliance visit to your research site without previous notification.*

---------------------------------------------

Chairman, HREC

Web-site: www.iphoau.org // E-mail: iph@oauife.edu.ng, iphhoauife@gmail.com

**Appendix 6**

R14/49 «Tit init name»

## HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

## CLEARANCE CERTIFICATE NO. M170343

| | |
|---|---|
| **NAME:** (Principal Investigator) | Dr Elizabeth Oziegbe |
| **DEPARTMENT:** | Anatomical Sciences<br>Kaduna Northwest Local Government Area<br>Kaduna State, Nigeria |
| **PROJECT TITLE:** | Maternal and Child Health Oral Health: Investigation of The Effect of Parity and Sociobehavioural Factors |
| **DATE CONSIDERED:** | 31/03/2017 |
| **DECISION:** | Approved unconditionally |
| **CONDITIONS:** | |
| **SUPERVISOR:** | Lynne Schepartz |
| **APPROVED BY:** | Professor P. Cleaton-Jones, Chairperson, HREC (Medical) |
| **DATE OF APPROVAL:** | 31/05/2017 |

**This clearance certificate is valid for 5 years from date of approval. Extension may be applied for.**

**DECLARATION OF INVESTIGATORS**

To be completed in duplicate and **ONE COPY** returned to the Research Office Secretary 3rd floor, Phillip Tobias Building, Parktown, University of the Witwatersrand. I/We fully understand the conditions under which I am/we are authorised to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions. Should any departure be contemplated, from the research protocol as approved, I/we undertake to resubmit to the Committee. **I agree to submit a yearly progress report**. The date for annual re-certification will be one year after the date of convened meeting where the study was initially reviewed. in this case, the study was initially review in March and will therefore be due in the month of March each year. Unreported changes to the application may invalidate the clearance given by the HREC (Medical).

Principal Investigator Signature Date

**PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES**

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

**HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)**

28 September 2017

**Dr Elizabeth Oziegbe**
Department of Anatomical Sciences
University of Witwatersrand

Sent by email to: elioziegbe@yahoo.com

Dear Dr Oziegbe

**Re:** **Protocol Ref no: M170343**
**Protocol Title:** Maternal and Child Oral Health Status: Investigation of the Effect of Parity and Socio-behavioural Factors in Nigeria
**Principal Investigator:** Dr Elizabeth Oziegbe
**Protocol Amendment: Change of Proposed Study Area**

This letter serves to confirm that the Chairman of the Human Research Ethics Committee (Medical) has approved the protocol amendment for the abovementioned protocol, as detailed in your letter dated 21 September 2017.

Thank you for keeping us informed and updated.

Yours Sincerely,

L. Moeng ................................................
**Mr Lebohang Moeng**
**Administrative Assistant**
**Human Research Ethics Committee (Medical)**

UNIVERSITY OF THE WITWATERSRAND
OFFICE OF THE DEPUTY VICE CHANCELLOR RESEARCH
2 8 SEP 2017
RESEARCH OFFICE HREC (Medical)
JOHANNESBURG

Research Office Secretariat: Faculty of Health Sciences, Phillip Tobias Building, 3rd Floor, Office 302, Corner York Road and 29 Princess of Wales Terrace, Parktown, 2193 Private Bag 3, Wits 2050 I **T**+27 (0)11-717-1234/2656/2700/1252 **E**: Lebo.Moeng@wits.ac.za I **Office E** HREC-Medical.ResearchOffice@wits.ac.za IWebsite: www.wits.ac.za/research/about-our-research/ethics-and-research-integrity/

**Appendix 7 (Turnitin report)**

Dr

ORIGINALITY REPORT

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