Study of the Association of Diabetes Mellitus and Orodental Health in Rural Communities of Nigeria

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Certificate of Authorship

I hereby declare that this submission is my work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person nor material which to a substantial extent has been accepted for the award of any other degree or diploma at Charles Sturt University or any other educational institution, except where due acknowledgment is made in the thesis. Any contribution made to the research by colleagues with whom I have worked at Charles Sturt University or elsewhere during my candidature is fully acknowledged. I agree that this thesis be accessible for the purpose of study and research in accordance with the normal conditions established by the Executive Director, Division of Library Services or nominee, for the care, loan and reproduction of these.

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Signature: ………………………………

Date: 31 July 2017
Dedication

This thesis is dedicated to God Almighty, whose constant love sustained me throughout my Doctor of Philosophy program.
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My profound gratitude goes to God Almighty for His guidance, providence and sustenance throughout my Doctor of Philosophy program. I lack words to explain the undeserved favour and mercy shown me, particularly when least expected.

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Ethics Statement

The study was approved by the Charles Sturt University Human Ethics Committee, approval number: 2015/286 (Appendix V) and complies with the standards set out by the Helsinki agreement for human research.
List of Acronyms and Abbreviations

1. µmol/L – Micromole per liter
2. ADA – American Diabetes Association
3. AGES – Advanced glycation end-product
4. AIC – Akaike information criterion
5. AIDS – Acquired Immune Deficiency Syndrome
6. AKTH – Aminu Kano Teaching Hospital
7. ALT – Alanine aminotransferase
8. AST – Aspartate aminotransferase
9. BANA – N-benzyl-DLarginine-2-naphthylamide
10. BGL – Blood glucose level
11. BMI – Body mass index
12. BOP – Bleeding on probing
13. BP – Blood pressure
14. CAL – Clinical attachment loss
15. CDC – Center for Disease Prevention and Control
16. CEJ – Cement-enamel junction
17. CHA – Catholic Hospital Abbi
18. CI – Confidence interval
19. cm – Centimeter
20. CPITN – Community Periodontal Index for Treatment Needs
21. CRP – C-reactive protein
22. CSU – Charles Sturt University
23. CVD – Cardiovascular disease
24. DEAR – Discrimination, Education, Adoptability, Relevance
25. DM – Diabetes mellitus
26. EBGH – Eku Baptist Government Hospital
27. FAO – Food and Agricultural Organisation
28. FBG – Fasting blood glucose
29. FGM – Free gingival margin
30. FMA – Full mouth assessment
31. GCF – Gingival crevicular fluid
32. GGT – Gamma-glutamyltransferase
33. GMRDO – Global Medical Research & Development Organisation
34. GMRDO – Global Medical Research and Development Organisation
35. GR – Gingival recession
36. HC – Hip circumference
37. HDL – High density lipoprotein
38. HDL-C – High density lipoprotein-cholesterol
39. HIV – Human Immunodeficiency Virus
40. HREC – Human Research Ethics Committee
41. IDF – International Diabetes Federation
42. IFG – Impaired fasting glucose
43. IGT – Impaired glucose tolerance
44. IL-1β – Interleukin 1β
45. ILs – Interleukins
46. IU/L – International unit per liter
47. Kg – Kilogram
48. LASUTH – Lagos State University Teaching Hospital
49. LGA – Local government area

50. LMIC – Low-mid-income country

51. MANOVA – Multivariate analysis of variance

52. MetS – Metabolic syndrome

53. mg/dL – Milligrams per deciliter

54. mmHg – Millimeters of mercury

55. mmol/L – Millimoles per liter

56. MMPs – Matrix metalloproteinases

57. NCEP ATP – National Cholesterol Education Program Adult Treatment Program

58. NGN – Nigerian naira

59. NHANES – National Health and Nutrition Examination Survey

60. NHLBI – National Heart, Lung and Blood Institute

61. NPC – National Population Commission

62. OAUTH – Obafemi Awolowo University Teaching Hospital

63. ODI – Orodental disease indicator

64. P – Porphyromonas

65. PACCS – Prediabetes and Cardiovascular Complications Study

66. PD – Periodontal disease

67. PGE_2 – Prostagladin E2

68. PMN – Polymorphonuclear leucocyte

69. RANKL – Receptor activator of nuclear factor kB ligand

70. RBS – Random blood sugar

71. ROS – Reactive oxygen species

72. SD – Standard deviation
73. SPSS – Statistical Package for Social Sciences
74. SSA – Sub-Saharan Africa
75. STEPS – STEPwise approach to non-communicable disease risk factor surveillance
76. T1DM – Type 1 diabetes mellitus
77. T2DM – Type 2 diabetes mellitus
78. TC – Total cholesterol
79. TG – Triglyceride
80. TNF-α – Tumour necrosis factor
81. UBTH – University of Benin Teaching Hospital
82. UDM – Undiagnosed diabetes mellitus
83. UK – United Kingdom
84. UNTH – University of Nigeria Teaching Hospital
85. UPTH – University of PortHarcourt Teaching Hospital
86. USA – United States of America
87. USD – United States dollar
88. WC – Waist circumference
89. WHO – World Health Organisation
90. WHR – Waist-hip ratio
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List of Publications and Conference Papers Related to this Study

Journal Articles Published


Conference Papers


Other Publications During Candidature Relevant to Current Study


Abstract

Diabetes mellitus (DM) and oral health have been reported to be linked, and showed a steady rise in prevalences. Despite evidence for the bi-directional relationship of these diseases, data to substantiate the association in Nigeria are lacking. Hence, it is necessary to study the prevalences of DM and orodental diseases; and their relationship as well as ascertaining the feasibility of opportunistic screening of DM during dental visits. First, a literature review of epidemiological and clinical studies was undertaken and it highlighted co-morbidity of the diseases in Nigeria; suggesting evidence of association of DM and orodental diseases. The distribution of the co-morbidity was more in the geopolitical zone (South-South) of the study location compared to other geopolitical zones of the country. Second, population-based and dental clinic-based data were collected to validate the reported relationship of the diseases. Prevalences of hyperglycaemia in Ndokwa communities and the dental clinics were 56.8% and 63.4%, respectively. This is perhaps the first study on community-based and hospital-based prevalences of hyperglycaemia in orodental diseases in Nigeria. Overall, 43.5% of the participants had orodental disease indicator (ODI); and 19.5% of the dental clients had periodontal disease (PD). Co-morbidity of 24.3% of hyperglycaemia and ODI was observed. The highest prevalence of the association of hyperglycaemia and individual clinical orodental parameters was 64.1%, and the least was 21.3%. Findings of the study support evidence of the relationship between the DM and orodental diseases. This therefore indicates that, DM can be screened at dental clinics and vice versa. It also indicates that education programs on DM need to
highlight oral health and vice versa. The novelty of this study is that it provides evidence for opportunistic screening of hyperglycaemia in oral health clinics in Nigeria, since screening of these conditions is currently not routinely carried out till overt symptoms present. This study stresses the need for early community DM screening, as it is cost-effective. The study reports a triangular relationship between metabolic syndrome (MetS) components and PD. It also reveals another triangular association between hyperglycaemia, liver enzymes and periodontitis. A family case report indicates that 55% of the family members of the concerned subject had preventable cardiovascular disease risk factors. The study also shows that large numbers of people are hyperglycaemic, and some may be living lifestyles that promote DM. Anthropometric indices were shown to be promising in diabetes prediction and will be useful DM screening tool in rural communities. Public health education remains a feasible approach to controlling the discussed diseases, especially in rural communities where low literacy and poverty are found.
CHAPTER 1: INTRODUCTION
ASSOCIATION OF DIABETES MELLITUS AND ORODENTAL HEALTH IN RURAL NIGERIA: RESEARCH OVERVIEW

1.1 Background

Diabetes mellitus (DM) is a growing healthcare problem, and the incidence and prevalence are increasing in developed and developing nations (Beulens, Grobbee, & Nealb, 2010). Furthermore, type 2 DM (T2DM), which is the focus of this study commonly occurs concomitantly with oral manifestations that impact dental care (Ship, 2003). It has been shown that poor oral health and periodontitis are associated with chronic diseases including T2DM (Preshaw et al., 2012), and that DM especially T2DM is a significant risk factor for periodontitis (Chee, Park, & Bartold, 2013). This association forms the basis of this study, which looked further into opportunistic screening of DM in dental settings.

There is indication that orodental parameters such as bleeding on probing (BOP), gingivitis and periodontitis are strongly associated with prediabetes. This therefore suggests that if association between prediabetes and gingival/periodontal inflammation is established, then some orodental parameters can constitute screening tools for identification, prevention and prediction of diabetes. That being the case, dental clinics can be useful in identifying undiagnosed diabetic subjects. Identification of individuals at risk of various diseases using simple and affordable methods as well as ‘opportunistic’ screening has been suggested (Engelgau, Narayan, & Herman, 2000), and the association of periodontitis and metabolic syndrome
(MetS) has been documented (Suvan, D’Aiuto, Moles, Petrie, & Donos, 2011). It has been reported that periodontal disease (PD) is associated with MetS, since the relationship of some components of MetS and PD has been suggested (Gurav, 2014).

There are dental clinics, and primary healthcare centres in Nigeria as well as orodental health professionals who are abundantly distributed in the South-South geopolitical zone of Nigeria (Labiran, Mafe, Onajole, & Lambo, 2008), where Delta State, the location for this study communities belongs. There are studies that have reported screening and identification of diabetes in patients that present with orodental diseases, but there is dearth of information on opportunistic screening of DM in Nigeria. It is this gap that this study is set to address with a view to promoting early identification of DM and/or prediabetes, thereby facilitating timely interventions against progression and complications.

The study involved Ndokwa communities: Abbi and Kwale (community-based) and dental clinic (institution-based) of Eku Baptist Government Hospital (EBGH) all in Delta State, Nigeria. While the former is in Ndokwa West Local Government (LGA), the latter is situated in Ethiope East LGA (Figure 1.1). In this study, ‘rural communities’ refers to Ndokwa West LGA as well as rural communities served by EBGH. Those who participated in the study met all the inclusion criteria. Determination of sample size for Ndokwa communities was based on specifications of the parent research body; which is Prediabetes and Cardiovascular Complications Study (PAACS) (Nwose et al., 2013). The institution-based
study population was calculated, using Epi-Info software (version 7.1, CDC Atlanta USA).

Data collection involved use of questionnaires, anthropometric measurements, diagnostic laboratory and periodontal examination. Questionnaire administration preceded anthropometry and other measurements as shown in Figure 1.2. Anthropometric parameters measured for the study included waist circumference (WC), hip circumference (HC), weight, height, waist-hip ratio (WHR), body mass index (BMI) and blood pressure (BP). The study also measured the following diagnostic laboratory parameters: fasting blood glucose (FBG), total cholesterol (TC), triglycerides and high density lipoprotein-cholesterol (HDL-C). Random blood glucose (RBS) was also collected from the dental patients, after FBG test. This was exclusively for modelling study (section 4.8 of Chapter 4).

Another measurement considered was periodontal examination, which included full mouth assessment (FMA), bleeding on probing (BOP), clinical attachment loss (CAL) and gingival recession (GR). Data were analysed, and results presented in Tables and Figures. The preceding discussions are detailed in Chapter 3, where they are written in sections/subsections.
Figures 1.1: Maps showing the study area in Delta State (Ofuoku, 2012) (a), Nigeria (PremiumTimes, 2017) (b)
The diagram (flow chart) for the study design is shown in Figure 1.2.

Note: Previously diagnosed DM and MetS clients will not be part of steps 7 and 8.

Figure 1.2: Flow chart of the overall study design
1.2 Significance of the Study

It is known that inhabitants of Ndokwa communities show poor health-seeking behaviour, especially concerning cardiovascular disease (CVD) and diabetes (Oguoma, Nwose, & Bwititi, 2014); and also in regards to dental clinic visit for orodental health problems (Azodo & Amenaghawon, 2013). The prevalences of DM and orodental diseases are a huge challenge in Nigeria. Hence, there is need for data contribution from rural communities and health institutions in regards to the association of these diseases. The present study collected such data in Ndokwa communities and EBGH to validate the association. The overreaching aim of the study was to establish the feasibility of opportunistic screening of DM in dental settings with a view to enhancing early identification and management of DM/prediabetes in Nigeria. It is anticipated that establishment of a screening protocol, coupled with other DM control strategies, will stem the prevalence/incidence of the disease. The preceding can be represented with the acronym, ‘DEAR’ for discrimination, education, adoptability and relevance.

**Discrimination:** The prevalences of DM and orodental diseases are on the increase in Nigeria, and there is no agenda for routine screening of DM/prediabetes except for antenatal clinic patients. A public health framework for early diagnosis and intervention against diabetes/prediabetes is yet to be realised, and data on opportunistic screening of diabetes in Nigeria and most countries are lacking. Hence, the
need for this study, which hopes to develop a screening protocol for early
detection of DM in dentists.

*Education:* Studies show a relationship between DM and orodental health,
but little is known about opportunistic screening of DM. The literature has
highlighted and given insight to opportunistic screening of DM and
prediabetes among individuals with dental/oral diseases/disorders. The
proposed study aims to bring to fore, a new approach to timely detection of
DM/prediabetes; allowing management of the disease before complications
present.

*Adoptability:* DM screening and its association with orodental diseases has
been a subject of concern. Two studies similar to the proposed study, with
adoptable methods are studies of Andriankaja and Joshipura (2014) and
Azodo and Amenaghawon (2013), and the methods in both studies were
relevant to the current research. The later study was on oral hygiene status
and practices, and the former involved more of clinical measurements. The
methodologies of both studies were therefore, adopted with modifications.

*Relevance:* Given the subtle nature of DM, establishing a framework for
early screening of the disease should help direct management interventions
appropriately. The research is relevant in reducing disease progression to a
controllable stage of morbidity and mortality as well as improve prognosis.

1.3 Overview of Study Layout

The Chapter 2 of this study is the literature review, which is already peer-
reviewed journal publication. It lays the premise for gaps in previous studies
that the ‘Results’ in Chapter 4 and ‘Discussion’ in Chapter 5 have addressed. Further, the aims, objectives and hypotheses of the study are highlighted. Chapter 3 discusses: ethical considerations, materials and methods utilized in biochemical and anthropometric measurements as well as in periodontal examination; and the questionnaires used in the study. Statistical tools employed in analyses of data are highlighted and justified. Chapter 4 gives an overview of results discussed in Chapter 5 to facilitate understanding of results’ presentation and discussions. The sequence of presentation of the Tables and Figures is also demonstrated here, and the rationale is to facilitate understanding of connectivity of the numbered sections. Chapter 5 comprises numbered and titled discussions of results, and each discussion starts with a preamble, and ends with a conclusion. The results are discussed, and compared with similar studies, and speculations made where necessary. Finally, Chapter 6 summarizes this study, and factors and strengths of the study are discussed as well as recommendations.
CHAPTER 2: CO-MORBIDITY OF DIABETES MELLITUS AND ORODENTAL DISEASES IN NIGERIA – CONSIDERATION OF OTHER RELEVANT LITERATURES

2.1 Introduction

Diabetes mellitus (DM) is a metabolic disorder characterised by chronic hyperglycaemia that results from defects in synthesis or secretion or action of insulin (ADA, 2010). It is a major cause of death and disability worldwide (Akter, Rahman, Abe, & Sultana, 2014; Murray et al., 2013), and the incidence of DM is increasing in developed and developing nations (Beulens et al., 2010). Global estimates report that 382 million people were diagnosed with diabetes in 2013, and the number is expected to increase to 592 million by 2035 (Guariguata et al., 2014). It is estimated that 4.6 million people die from diabetes yearly, accounting for 8.2% mortality rate from all causes throughout the world (IDF, 2013). DM is associated with concomitant oral manifestations that necessitate dental care (Ship, 2003).

Good oral health and absence of orodental disease enable an individual to eat, speak and socialise without discomfort or embarrassment, and contribute to the general well-being (Olusile, 2010). Oral diseases and orodental trauma constitute major health challenges globally (Anil, Varma, Preethanath, Anand, & Aldosari, 2012; Ndiaye, 2005; Petersen, Bourgeois, Ogawa, Estupinan-Day, & Ndiaye, 2005) and poor oral health has significant impact on general health, and several oral diseases are linked with chronic diseases such as diabetes (Petersen et al., 2005). Studies show that diabetics exhibit poorer oral health than non-diabetics in some oral
conditions such as periodontitis, xerostomia and caries lesions (Sandberg, Sundberg, Fjellstrom, & Wikblad, 2000), and a link between diabetes and PD has been reported, and shows that diabetics are at increased risk for periodontal complications (Lalla, 2007; Lalla, Kunzel, Burkett, Cheng, & Lamster, 2011; Ueno et al., 2010). Evidence from other studies implicates DM to be a risk factor for the development of PD, and this has been variously reviewed with confirmations from epidemiological data. The mechanisms that underpin the association of both diseases are not clearly understood, but aspects of immune functioning, neutrophil activity and cytokine biology are involved (Preshaw, 2008, 2013; Preshaw et al., 2012).

If an association between DM and orodental diseases exists, then this should allow development of opportunistic screening of DM and orodental diseases in DM and orodental health centres. Since the prevalence of DM is on the increase and most people remain undiagnosed, screening for DM and orodental diseases should lead to early diagnosis. This will possibly avert complications of the diseases, thus reducing the socioeconomic costs of the conditions, and will perhaps be beneficial to low-income communities. Evaluation of models for DM screening in medical setting, using objective and self-reported features has been reported (Kahn, Cheng, Thompson, Imperatore, & Gregg, 2009; Merakou, Knithaki, Karageorgos, Theodoridis, & Barbouni, 2015; Wilson et al., 2007). Model evaluation for DM screening is likely beneficial in identifying people with diabetes and orodental diseases, since both conditions are associated with each other. Identifying individuals at risk of developing diabetes with simple methods and opportunistic screening has been recommended (Engelgau et al., 2000).
Data from the National Health and Nutrition Examination Survey (NHANES) III (Borrell, Kunzel, Lamster, & Lalla, 2007), suggest that an algorithm using periodontal measures in dental settings, plus the risk factors known by patients such as family history of diabetes, may proffer a novel means to identify individuals with undiagnosed DM (UDM). The chairside method for the diagnosis of diabetes in dental settings has been variously reported (Debnath, Govila, Sharma, Saini, & Pandey, 2015; Kaur, Singh, & Sharma, 2013; Shetty et al., 2013; Suneetha & Rambabu, 2012), but the chairside method uses gingival crevicular blood, which cannot be used for screening blood glucose levels during periodontal examination (Debnath et al., 2015). Thus, the correlation between oral symptoms and diabetes provides means of early diagnosis (Ogunbodede, Fatusi, Akintomide, Kolawole, & Ajayi, 2005).

2.2 Literature Search Methods

Data published between May, 1970 and April, 2015 were used in writing this review. Electronic and manual searches using databases such as Google Scholar, African Journal Online, Medline, EBSCOhost (Health), ProQuest, Scopus, ScienceDirect (Elsevier SD), SAGE Journals Online, PubMed and Wiley Online Library were employed. The key terms used for the search included Nigeria, diabetes mellitus, T2DM, type 1 DM (T1DM), prediabetes, World Health Organisation (WHO) and International Diabetes Federation (IDF). Other search terms were oral health, periodontitis, dysglycaemia, orodontal diseases, metabolic syndrome, opportunistic screening and association. Studies not carried out in Nigeria as well as
animal studies and relevant studies undertaken in Nigeria constituted the exclusion and inclusion criteria, respectively. However, in some cases, studies carried out outside Nigeria were cited, if deemed relevant.

2.3 Diabetes and Prediabetes in Nigeria

The major burden of diabetes is now in developing countries rather than developed countries (Shaw, Sicree, & Zimmet, 2010) because there is a higher prevalence rate of T2DM among young to middle-aged people in developing countries (Cockram, 2000; Tieh & Dreimane, 2014). Eighty percent of cases of DM worldwide live in less developed countries (Shaw et al., 2010), and there is perhaps under-reporting of DM in African countries possibly due to the lack of research (Ogbera, Chinenyew, Onyekwere, & Fasanmade, 2006). This is also coupled most likely with scarcity of health provision such as health centres, hence some cases are not diagnosed and reported. Other reports suggest that under-reporting is a reflection that DM is not prioritised among the health care needs of the country, possibly due to emphasis on infectious diseases such as acquired immunodeficiency syndrome (AIDS) (Nwafor & Owhoji, 2001). DM is emerging as a major and challenging health problem, and Nigeria is currently undergoing rapid epidemiological transition in the distribution of metabolic disorders (Adediran, Akintunde, Edo, Opadijo, & Araoye, 2012). Perhaps this is as a result of migration and changing socioeconomic factors (Okoduwa, Umar, Ibrahim, Bello, & Ndidi, 2014).
### Table 2.1a: Population-based studies on diabetes mellitus in Nigeria

<table>
<thead>
<tr>
<th>Author(s)</th>
<th>Year of publication</th>
<th>Study location</th>
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<tbody>
<tr>
<td>Azange and Anizor (2012)</td>
<td>2012</td>
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</tr>
<tr>
<td>Akinjinni, Adeyoye, Akingbade, and Okerentugba (2014)</td>
<td>2014</td>
<td>Abeokuta, Ogun State</td>
</tr>
<tr>
<td>Enang et al. (2014)</td>
<td>2014</td>
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<td>Gezawa et al. (2015)</td>
<td>2015</td>
<td>Maiduguri, Borno State</td>
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<td>Isara and Okundia (2015)</td>
<td>2015</td>
<td>Esan South East, Edo State</td>
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<td>Jaja, Oduwole, Fetuga, and Abdus-Salam (2015)</td>
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<td>Kyari et al. (2014)</td>
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<td>Nwafor and Owoji (2001)</td>
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<td>Nwatu et al. (2015)</td>
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<td>Nyenwe, Odia, Ihekwaba, Ojule, and Babatunde (2003)</td>
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### Table 2.1b: Population-based studies on diabetes mellitus in Nigeria

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<td>Ogbu, Azodo, and Chinwuba (2013)</td>
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<td>Oguoma et al. (2015)</td>
<td>2015</td>
<td>Ndokwa, Delta State</td>
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<tr>
<td>Ojewale and Adejumo (2012)</td>
<td>2012</td>
<td>Oyo State</td>
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<tr>
<td>Okonkwo, Okoye, and Isichei (2013)</td>
<td>2013</td>
<td>Bukuru, Plateau State</td>
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<tr>
<td>Olatunbosun, Ojo, Fineberg, and Bella (1998)</td>
<td>1998</td>
<td>Ibadan, Oyo State</td>
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<tr>
<td>Omorogiwu et al. (2010)</td>
<td>2010</td>
<td>Ekpoma, Edo State</td>
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<tr>
<td>Osuji, Nzerem, Dioka, Meludu, and Onwubuya (2012)</td>
<td>2012</td>
<td>Naze, Owerri, Imo State</td>
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<tr>
<td>Owoaje, Rotimi, Kaufman, Tracy, and Cooper (1997)</td>
<td>1997</td>
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<tr>
<td>Sabir et al. (2013)</td>
<td>2013</td>
<td>Wamakko, Sokoto State</td>
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</table>
**Key of prevalence according to study location:**  †Obafemi Awolowo University Teaching Hospital (OAUTH), Osun State (Oyegbade, Abioye-Kuteyi, Kolawole, Ezeoma, & Bello, 2007); ‡University of Nigeria Teaching Hospital (UNTH), Enugu State (Ogbu & Neboh, 2009); *Aminu Kano Teaching Hospital (AKTH), Kano; ††University of PortHarcourt Teaching Hospital (UPTH), Rivers State; Lagos State University Teaching Hospital (LASUTH), Lagos State & National Hospital, Abuja (Chinenye et al., 2012); †† Federal Medical Centre, Owerri, Imo State (Iloh & Uchenna, 2014). The y-axis of Figure 2.1 represents percentage prevalence of DM/prediabetes, while x-axis represents names of authors.

**Figure 2.1: Prevalence of diabetes mellitus in Nigeria (hospital-based studies)**

There were 1.71 million people with DM in Nigeria in 2014, and this is projected to reach 4.84 million by 2030 (Guariguata et al., 2014). According to IDF (2013), the national prevalence of DM in Nigeria is 4.99%. It has been reported that 3.9 million adults between the ages of 20 – 79 years were diagnosed with DM in Nigeria, with T2DM accounting for about 90% of the cases (Chijioke, Adamu, & Makusidi, 2010). In most endocrine clinics in Nigeria, T2DM accounts for 90% - 95% of cases of diabetes (Ogbera & Ekpebegh, 2014). Several population-based studies have been done on DM in Nigeria (Tables 2.1a and b). Some of the hospital-based studies on
prevalence of DM/prediabetes in Nigeria are shown in Figures 2.1. The study of Chinenye et al. (2012) reports the highest prevalence of DM, and the least is reported by Oyegbade et al. (2007). The differences in prevalence may be attributed to socioeconomic and socio-cultural factors such as poverty and poor health-seeking behaviour as well as the 5 year gap between the 2 studies. The study that recorded the highest prevalence was multi-center, involving seven tertiary health institutions covering the six geopolitical zones of Nigeria. However, the reason for the observed prevalence in the multi-center study could largely be attributed to the fact that the study involved only diabetic subjects.

DM results in complications such as CVD, nephropathy, retinopathy, neuropathy, among others (Wu, Ding, Tanaka, & Zhang, 2014) and the increase in prevalence of DM, possibly coupled with a weak health system is responsible for deaths from these diabetic complications (Ekpenyong et al., 2012). This is profound in low-mid income communities (Guariguata et al., 2014) with weak health systems. The preceding implies that there is a rising incidence of DM in Nigeria, which may be underestimated due to lack of awareness and perhaps under-reporting. Reducing the prevalence of DM in Nigeria, calls for awareness of the disease; especially among rural inhabitants. This implies that if people could manage their DM, they would also reduce risk for orodental disease. In the early 1980s, the prevalence of DM was higher in the males than the females in Nigeria but since then, more females have been reported to have higher mean FBG levels than males (Figure 2.2). Again, the prevalence of high FBG level in both sexes is increasing, and this will lead to increases in DM thus diabetic complications
and risk for orodental diseases, since the conditions are reported to be linked (Preshaw et al., 2012).

Figure 2.2: Mean fasting blood glucose (FBG) levels of Nigerians

The reasons for rising prevalence of increased FBG levels in females than males (Figure 2.2) need to be explored to understand the approaches to stemming the increasing prevalence, which will reduce diabetic complications and risk for orodental diseases. Information on prevalence and knowledge about DM and its possible association with orodental health will help to control the spread of both diseases. The preceding also suggests more studies on prevalence of prediabetes be done since prevalence of e.g. T2DM in Nigeria is rising, especially in the young to middle-aged individuals (Shaw et al., 2010). The number of people with DM in Nigeria is high, coupled with the prediction that 4.84 million out of the estimated 182 million (NPC, 2010) people in Nigeria will have DM by 2030. Stemming the rising incidence of the disease can be achieved through for
instance, an opportunistic screening protocol for early identification and management of the disease.

2.4 Orodental Diseases in Nigeria

Oral diseases constitute major public health threat globally, and these diseases are dental caries, PD, tooth loss, oral mucosal lesion, oropharyngeal cancers, orodental trauma as well as oral fungal, viral and bacterial lesions due to e.g. human immunodeficiency virus/AIDS (HIV/AIDS) (Akhter, Hassan, Aida, Takinami, & Morita, 2008; Petersen et al., 2005). Poor oral health impacts on general health, and many oral diseases are associated with chronic diseases (Anil et al., 2012), particularly DM (Petersen et al., 2005; Preshaw et al., 2012). A review of oral health by WHO (Petersen, 2003) emphasised that oral diseases still occur among the underprivileged in developing and developed countries, despite huge improvements in oral health in several countries (Petersen et al., 2005; WHO, 2004).

PD is the most frequent oral disease, and a significant cause of tooth mortality among adults (Aderinokun & Dosumu, 1997; Danielson, Chinedu, Oluyemisi, Bashiru, & Ndubuisi, 2011). The prevalence of oral disease in Nigeria is 15 – 58% in those aged 15 years and above (Akpata, 2004) and the prevalence of PD as high as 98% has been recorded among the elderly (50 – 85 years) pensioners in Benin City (Okeigbemen, Jeboda, & Umweni, 2012), and this was linked to socioeconomic status, poor access to health services and risk behaviours such as smoking, intake of alcohol and carbohydrate-rich diet as well as poor oral hygiene (Cruz, Costa, Gomes
Filho, Vianna, & Santos, 2005; Danielson et al., 2011). Some population-based studies have been done on DM in Nigeria (Tables 2.2a and b). Hospital-based studies on prevalence of orodental diseases in Nigeria are shown in Figure 2.3, which shows that PD was the most prevalent oral disease, followed by dental caries and other oral pathologies were least prevalent.

The World Oral Report in 2003 identified oral diseases as a major global public health challenge (Petersen, 2003), and this is evidenced in Nigeria. For example, Azodo and Amenaghawon (2013) observed that oral hygiene and oral health practices were suboptimal in rural dwellers of Ndokwa communities. Of particular concern was the finding that over 94% of the study population had never visited the dental clinic (Azodo & Amenaghawon, 2013).

**Table 2.2a: Population-based studies on orodental diseases in Nigeria**

<table>
<thead>
<tr>
<th>Author(s)</th>
<th>Year of publication</th>
<th>Study location</th>
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<tbody>
<tr>
<td>Abiola, Eyitope, Sonny, and Oyinkan (2009)</td>
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<td>Alakija (1983)</td>
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<td>Braimoh, Umanah, and Ilochonwu (2014)</td>
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<td>Denloye, Ajayi, and Bankole (2005)</td>
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<tr>
<td>Kubota et al. (1990)</td>
<td>1990</td>
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<tr>
<td>Umoh and Azodo (2013)</td>
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Table 2.2b: Population-based studies on orodental diseases in Nigeria

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<td>MacGregor (1980)</td>
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<td>Ogundele and Ogunsile (2008)</td>
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<td>2015</td>
<td>Elekahia &amp; Obigbo, Rivers State</td>
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<td>Olaitan (2005)</td>
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<td>Oziegbe and Esan (2013)</td>
<td>2013</td>
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<td>Sofola, Folayan, and Oginni (2014)</td>
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<td>Sowole and Sote (2007)</td>
<td>2007</td>
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<tr>
<td>Udoye et al. (2009)</td>
<td>2009</td>
<td>Enugu North, Enugu State</td>
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<tr>
<td>Umoh and Azodo (2013)</td>
<td>2013</td>
<td>Benin City, Edo State</td>
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</table>
Key: PD = Periodontal disease/periodontitis and DC = Dental caries. Key of prevalence according to study location: †AKTH (Sanu, Oredugba, & Adebola, 2010), ‡UPTH (Omitola & Arigbede, 2012), †*OAUTH (Oginni, Adeleke, & Chandler, 2014), †″LASUTH (Onigbinde, Sorunke, Braimoh, & Adeniyi, 2015), †§UPTH (Eigbobo, Gbujie, & Onyeaso, 2014), †**OAUTH (Oginni, Adeleke, Mejabi, & Sotunde, 2015), University of Benin Teaching Hospital (UBTH) (Azodo & Amenaghawon, 2013), UBTH (Ojehanon & Akhionbare, 2007), OAUTH (Owotade, Ogunbodede, & Lawal, 2005). The y-axis of Figure 2.3 represents percentage prevalence, while x-axis represents names of authors.

Figure 2.3: Prevalence of Orodental Diseases in Nigeria (hospital-based studies)

Most oral health surveys in Nigeria have been sporadic (Akpata, 2004), however, these and a few nationwide surveys (Adegbembo, El-Nadeef, & Adeyinka, 1995) show that PD and dental caries are two major oral health problems (Ajayi & Arigbede, 2013; Chukwumah, Azodo, & Orikpete, 2015; Olusile, 2010), and the minor ones include malocclusion, traumatised anterior teeth, dental fluorosis and tumours (Akpata, 2004). Studies report high prevalence rates of PD (Adegbembo et al., 1995; Olusile, 2010), and that occurrence of the disease is related to oral hygiene and socioeconomic status. The oral health of adult diabetic patients were assessed by Ogunbodede et al. (2005) who compared diabetics with non-diabetics; halitosis, a sign of PD was observed in 64.6% of the diabetics and 72.2% in non-diabetics, while periodontal abscess was seen in 10.8% and 7.4% of the diabetics and non-diabetics, respectively. The study reported that with adequate metabolic control, the oral health of a diabetic might not be significantly different from that of a non-diabetic, except xerostomia.

It appears that there is poor orodental health in Nigeria, and this is common in rural communities where there are gaps in individuals’ understanding of orodental health. In African regions where poverty prevails, oral health
receives low priority, and limited resources are invested in the control of e.g. HIV/AIDS, malaria and tuberculosis rather than oral diseases (Ndiaye, 2005).

**Keys:** ▲ Orodental disease, ● Diabetes mellitus. This is based on data of population-based studies accumulated over the years by the authors shown in Tables (2.1a and b) and (2.2a and b).

**Figure 2.4: Burden of Diabetes Mellitus and Orodental Diseases in Nigeria**

Figure 2.4 shows that DM and orodental diseases are abundant in the South-South as well as South-East geopolitical zones. This is based on data from population-based studies accumulated over the years by the authors shown in Tables (2.1a and b) and (2.2a and b). The abundance of both diseases in the aforementioned zones is a pointer of a possible co-morbidity of the diseases. It is possible that many studies have not been carried out in other areas resulting in lack of data.
2.5 Association of Diabetes and Orodental Diseases

DM is a systemic disease that is associated with developing PD (Chávarry, Vettore, Sansone, & Sheiham, 2009; Preshaw et al., 2012; Salvi, Carollo-Bittel, & Lang, 2008). Studies on the association of DM, periodontal health and subsequent tooth loss report of a positive correlation between the conditions. This is with particular reference to the effect of DM on periodontal status (Campus, Salem, Uzzau, Baldoni, & Tonolo, 2005; Jung, Kim, Jin, Cho, & Lee, 2013; Y. S. Khader, Dauod, El-Qaderi, Alkaafajei, & Batayha, 2006; Taylor & Borgnakke, 2008). There is indication of biological and epidemiological relationship between PD and DM, particularly T2DM (Andriankaja & Joshipura, 2014; Ueno et al., 2010). The chance of developing periodontitis is increased by approximately three-folds in diabetics compared to non-diabetics (Mealey & Ocampo, 2007). Some cross-sectional and longitudinal studies among Pima Indian population showed that DM was a major risk factor for periodontitis. The study reported the prevalence and incidence to be higher among those with T2DM compared to subjects without (Nelson et al., 1990; Taylor, Burt, Becker, Genco, & Shlossman, 1998), and the increased risk of periodontitis was approximately three-folds in those with T2DM (Emrich, Shlossman, & Genco, 1991).

Strauss et al. (2010) analysed data on DM and PD of the NHANES (2003 – 2004), and reported that 93% of subjects with moderate and severe PD as well as UDM, could be classified in the criteria for DM risk according
ADA. It has been emphasised that treatment of PD may enhance glycaemic control in individuals with DM (Simpson, Needleman, Wild, Moles, & Mills, 2010; Teeuw, Gerdes, & Loos, 2010). Most studies have been centered on T2DM as a risk factor for development of periodontitis, possibly due to its historical development in patients in their 40s and 50s. Nevertheless, T1DM is also implicated as a risk factor for periodontitis. Diabetic patients, including children and adults should be considered at risk of periodontitis (Preshaw et al., 2012), and a study showed that around 10% of children with T1DM (<18 years) presented with increased attachment loss and bone loss, notwithstanding comparable plaque scores (Cianciola, Park, Bruck, Mosovich, & Genco, 1982).

Lalla et al. (2007) in their study on diabetic children (6 – 8 years old) and non-diabetic controls, observed that the proportion of sites with indication of periodontitis was higher in diabetic children (≥20% and 8% of sites, respectively). It is crucial to recognise the need to study the association of DM with orodental disorders, and a variety of oral conditions including xerostomia and candidal infections are linked with DM (Preshaw et al., 2012).

2.6 Pathogenic and Pathological Relationship in Diabetes and Orodental Diseases

Knowledge of the pathogenic/pathological role in the relationship between DM and orodental diseases is helpful in understanding the association. Periodontal pathogens have been shown to occur in diabetic and non-diabetic subjects. Thorstensson, Dahlen, and Hugoson (1995) reported that
more diabetics compared to non-diabetics harboured *Porphyromonas gingivalis*. A study on young Japanese with T1DM validated some of the findings of Thorstensson et al. (1995), with Takahashi (2001) reporting that a major part of the subjects with periodontitis had *P. gingivalis* and *P. intermedia* than those without periodontitis. A study showed a higher prevalence of *P. gingivalis* in T2DM subjects, compared with non-diabetic controls (Campus et al., 2005). These studies signify probable variations in microbial composition of subgingival biofilm between diabetic subjects and non-diabetics, but the clinical importance remains uncertain. Some disparities may occur from the effect of DM in changing the local metabolic environment within the periodontal pocket, favouring the growth of certain microbial species (Preshaw et al., 2012). When blood glucose level is poorly controlled, the resultant high levels in oral fluids may help micro-organisms grow, leading to PD (Fiske, 2004). DM has been reported to associate with orodental disorder, and the present study is to confirm the findings in a local context. This study will ascertain the extent of the relationship of both conditions as well as the feasibility of opportunistic screening of DM at dental settings.

It has been postulated that the mechanism for diabetic effect on PD is that diabetes-enhanced inflammation and apoptosis impact on the periodontal tissues (Graves, Liu, & Oates, 2007). Inflammation is the common feature of the pathogenesis of DM and orodental disorders such as periodontitis. Both T1DM and T2DM are associated with elevated levels of inflammation (Dandona, Aljada, & Bandyopadhyay, 2004), and inflammatory response is marked by dysregulated release of host-derived mediators of inflammation.
and tissue breakdown (Preshaw et al., 2012). The most widely studied mediators are interleukins (ILs), prostaglandin, tumour necrosis factor-α (TNF-α), receptor activator of nuclear factor κB ligand (RANKL), matrix metalloproteinases (MMPs), T-cell regulatory cytokines and chemokines, and these mediators are involved in periodontal pathogenesis (Preshaw & Taylor, 2011); which impacts on DM development. The pattern and rate of disease progression is dependent on the totality of inflammatory response in the periodontal tissues (Kinane, Preshaw, & Loos, 2011).

It is reported that inflammation plays an important role in the pathogenic mechanisms linking DM and periodontitis, and both T1DM and T2DM are associated with high levels of systemic markers of inflammation (Dandona et al., 2004). The increased inflammatory state in DM is implicated in microvascular and macrovascular complications, and it is apparent that hyperglycaemia can lead to the activation of pathways that elevate inflammation, oxidative stress and apoptosis (Brownlee, 2005b). Inflammation in the periodontal tissue is increased by diabetes, and gingival crevicular fluid (GCF) levels of PGE2 and IL-1β are elevated in patients with T1DM who have either gingivitis or periodontitis compared to non-diabetics with the same level of PD (Salvi et al., 1997). Diabetic patients with severe periodontitis exhibit depressed polymorphonuclear leucocyte (PMN) chemotaxis compared to those with mild periodontitis (Manouchehr-Pour, Spagnuolo, Rodman, & Bissada, 1981). In addition, diabetes sufferers with severe periodontitis show defective PMN apoptosis (Graves, Liu, Alikhani, Al-Mashat, & Trackman, 2006), and this may increase accumulation of PMNs in the periodontal tissue. Thus, giving rise to
increased tissue destruction facilitated by frequent release of MMPs and reactive oxygen species (ROS) (Preshaw et al., 2012).

Furthermore, accumulation of advanced glycation end-products (AGEs) in periodontal tissues, possibly involves up-regulating periodontal inflammation in DM. The production of inflammatory mediators such as IL-1β, TNF-α and IL-6 takes place when AGE binds to its receptor (RAGE) (Lalla, Lamster, Stern, & Schmidt, 2001). The formation of AGEs leads to the production of ROS, which facilitates oxidant stress; and the vascular injuries implicated in some diabetes complications are due to endothelial cell changes that occur (Vlassara, 2001). Increased susceptibility of periodontitis associated with DM may be influenced by apoptosis. The occurrence of apoptosis in matrix-producing cells may limit the chances for repair in inflamed tissues. Inducing tissue injury by inoculation of *P. gingivalis* leads to increased fibroblast apoptosis (Liu, Desta, He, & Graves, 2004), indicating another mechanism by which the ability to repair is inflamed in periodontal tissues (Preshaw et al., 2012).

Substantial evidence of an advanced state of PD among smokers has been documented (Kubota, Tanno-Nakanishi, Yamada, Okuda, & Ishihara, 2011; Vouros, Kalpidis, Chadjipantelis, & Konstantinidis, 2009). S. Singh et al. (2000) suggested that an essential constituent of cigarette smoke, aryl hydrocarbons possess the ability to inhibit bone formation, especially where PD-causing bacterial co-factors exist. This perhaps explains how periodontal bone loss is associated with cigarette smoking. Smoking of tobacco exerts destructive effect on periodontal tissues, and facilitates the rate of developing PD (Zini, Sgan-Cohen, & Marcenes, 2011). There is
indication that these aryl hydrocarbons may catalyse vascular disease progression, as measured by vascular calcification (Usman, 2004). There is a link between smoking and DM and its complications, including neuropathy, nephropathy, retinopathy, erectile dysfunction and hypertension; and abstinence from smoking is a significant risk factor in the management of DM (Haire-Joshu, Glasgow, & Tibbs, 1999). Abstinence from smoking also implies control of PD, since it is a major risk factor for development of the disease (Vouros et al., 2009).

The severity of PD in DM may signal a change in the pathogenic potential of bacteria, facilitating breakdown of periodontal tissues (Ebersole, Holt, Hansard, & Novak, 2008; Southerland, Taylor, Moss, Beck, & Offenbacher, 2006), and this leads to recurrent and severe periodontal tissue breakdown (Ueno et al., 2010). The metabolic state in DM is affected by PD, and Gram negative anaerobic bacteria involved in periodontal infections probably worsen the poor glycaemic control as well as increase the chances of diabetes complications (Hanindriyo, Yoshihara, Hirotomii, & Miyazaki, 2013; Mealey & Ocampo, 2007; Nagpal, Yamashiro, & Izumi, 2015; Taylor & Borgnakke, 2008).

2.7 Could Co-morbidity of Diabetes Mellitus and Orodental Diseases Favour Opportunistic Screening of Diabetes?

The association of DM and orodental diseases holds a promise into developing a screening protocol of DM in Nigeria, using dental setting. Two studies that are related to this study were identified: Ogunbodede et al. (2005) and Ojehanon and Akhionbare (2007). Their studies were on oral
health status of diabetic patients and prevalence of undiagnosed diabetes in dental clinic, respectively. Both studies were institutional (dental setting), but with different objectives from the present study. The proposed study seeks to establish an opportunistic screening protocol of DM in dental settings. Opportunistic screening of DM is a recommended screening protocol by WHO/IDF (WHO, 2003). Perhaps, research involving DM and orodental health will bring to fore a novel and timely approach to detect diabetes in Nigeria. If early identification of DM, possibly through opportunistic screening in dentistries is overlooked, a potential screening protocol may be compromised and future diabetes burden is possibly imminent.

2.8 A Brief on Cost-Effectiveness of Community Diabetes Screening

Screening for DM has been recommended to reduce the burden of the disease (ADA, 2004). Early detection and treatment of T2DM seem a logical preventive approach to adopt for a number of cost-saving reasons (Toscano et al., 2015). Globally, cost of diabetes care is exorbitant, amounting to billions of United States Dollar (USD). For instance, at least USD 465 billion was spent on DM care globally in 2011, and this constituted about 11% of the total health expenditure in adults. The proportion of these costs was invested in DM care in low-middle-income-countries (LMICs), where 80% of people with diabetes live (Mbanya, Motala, Sobngwi, Assah, & Enoru, 2012; Oguejiofor, Odenigbo, & Onwukwe, 2011). Several countries have implemented opportunistic selective T2DM screening in high-risk populations (WHO, 2003).
Incorporating such a public health approach into standard practice requires measuring the estimated benefits of population screening in reducing long-term complications against the long-term costs it generates (Herman, 1999).

While it is reported that diabetes screening is cost-effective (Li, Zhang, Barker, Chowdhury, & Zhang, 2010), several factors are known to define cost-effectiveness. Hence, it is suggested that screening high-risk individuals is worthwhile (O'Connor, Rush, Cherney, & Pronk, 2000). However, it is difficult to identify high-risk individuals in LMIC such as Nigeria, especially in rural communities where health care seeking behaviour is poor. Thus, this negates screening of only high-risk individuals but mass screening, which will likely be subsidised or with minimal cost. Mass screening for diabetes has been reported to be beneficial in statistical model-based studies (Kahn et al., 2010). There is a recommendation by WHO expert group that countries define policies for diabetes diagnosis and treatment (WHO, 2003) and careful application of health economic principles to medical decision making, especially in diabetes control may help improve the value of health care in Nigeria.

2.9 Metabolic Syndrome and Orodental Disease

Since MetS is positively associated with development of DM, it is therefore important to review PD in the context of MetS. The association between systemic diseases and periodontitis has been reported (Gurav, 2014; Jaramillo et al., 2017). This association is believed to arise from systemic oxidative stress and exuberant inflammatory response (Lamster & Pagan, 2017). Periodontitis and MetS are multi-factorial diseases with a common
inflammatory pathway (Alhabashneh, Khader, & Asa’ad, 2015). Low-grade systemic inflammation, which is reported by elevated levels of inflammatory mediators occur in most individuals. The inflammatory mediators involved are C-reactive protein (CRP), interleukin-6 (IL-6) and TNF-α. It is known that periodontitis subjects also have high levels of inflammatory markers such as CRP, IL-3 and TNF-α (Li, He, Sha, & Luan, 2009; Morita et al., 2010).

MetS is a configuration of multiple abnormalities characterised by hyperglycemia, central obesity, abnormal cholesterol and triglyceride levels and hypertension, and each of these components has been shown to associate with periodontitis (Gurav, 2014; Kikui et al., 2017). Studies report of a positive relationship between periodontitis and MetS (D’Aiuto et al., 2008; Khader et al., 2008; Shimazaki et al., 2007), suggesting that subjects displaying components of MetS should be submitted to periodontal examination (Gurav, 2014). It is also observed that periodontitis shares common risk factors with MetS, and these include hyperglycemia, obesity, dyslipidaemia and elevated blood pressure (Han, Lim, Sun, Paek, & Kim, 2010a). There is considerable evidence establishing diabetes as risk factor for chronic periodontitis (Chávarry et al., 2009; Salvi et al., 2008) as well as indication of biological and epidemiological relationship between PD and DM, particularly T2DM (Andriankaja & Joshipura, 2014; Ueno et al., 2010). The chance of developing periodontitis is increased by approximately three-folds in diabetic individuals compared with non-diabetics (Mealey & Ocampo, 2007).
It has been suggested that obesity is second to smoking as the highest risk factor for inflammatory periodontal tissue destruction (Nishida et al., 2005). Examination of the NHANES III data showed that WHR, BMI, fat-free mass and subcutaneous fat significantly correlated with PD (Wood, Johnson, & Streckfus, 2003). Visceral fat has been reported as the most appropriate indicator of obesity in relation to periodontitis, and obesity can act as potential risk factor for periodontitis (Han, Lim, Sun, Paek, & Kim, 2010b). It is suggested that dyslipidaemia is associated with periodontitis, but its role as a risk factor is not clear (Saito & Shimazaki, 2007). Bidirectional relationship between dyslipidaemia and PD has been proposed, and there appears to be alteration in the phenotype of immune cells as a result of elevation in levels of serum lipid and pro-inflammatory cytokines (Fentoglu & Bozkurt, 2008).

2.10 Association of Hyperglycaemia, Liver Enzymes and Periodontitis

Relationship between DM/prediabetes and liver function has been reported, and individuals with T2DM have a higher incidence of liver abnormalities than those without diabetes (Harris, 2005; Mathur, Mehta, Kapoor, & Yadav, 2016). Serum alanine aminotransferase (ALT) and aspartate aminotransferase (AST) are liver enzymes; markers of liver damage and part of liver function testing panel (Hanley et al., 2004). ALT is specific for liver function, and a marker of liver inflammation and injury, while AST is less specific because it also found in other tissues (Lee, Silventoinen, Jacobs Jr, Jousilahti, & Tuomileto, 2004). Increase in activities of these enzymes, especially ALT is associated with a two-fold increase in the risk of T2DM.
independent of conventional risk factors (Cho et al., 2007). The Insulin Resistance Atherosclerosis Study confirmed an independent predictivity of AST and ALT for incident diabetes (Hanley et al., 2004). Nannipieri et al. (2005) showed that ALT is associated with impaired glucose tolerance (IGT) and diabetes, while AST was associated with IGT only. High serum activities of gamma-glutamyltransferase (GGT) and ALT are associated with increased T2DM risk, and may be useful in detecting risk of developing T2DM in Chinese population (Wang, Koh, Yuan, & Pan, 2016).

An association between activities of liver enzymes and PD has been reported. For instance, a Japanese study showed that individuals with PD had increased activities of liver enzymes, including ALT and AST (Saito, Shimazaki, Koga, Tsuzuki, & Ohshima, 2006). Another study in Japan suggested that young males with PD has significantly elevated activities of ALT (Furuta et al., 2010). The liver is a metabolic hub, hence can influence the identified link because of the relationship with each of hyperglycaemia and periodontitis (Wang, Koh, et al., 2016). This study will substantially contribute to literature in Nigerian context, in addition to the studies of Levine (2013), Andriankaja and Joshipura (2014) in Puerto Rico as well as Azodo and Amenaghawon (2013), especially as such data lack in Nigeria. The study of Levine (2013) suggested a triangular relationship of obesity, diabetes and periodontitis. The report in Puerto Rico was on prediabetes and gingivitis/periodontitis, and established a relationship between prediabetic condition and gingivitis/periodontitis. The mentioned study in Nigeria by Azodo and Amenaghawon (2013) on oral hygiene practices showed that 94% of the study population had not visited the dentist for orodental care.
Since hyperglycaemia is associated with PD, and PD has a relationship with liver enzymes, there is indication of a triangular nexus involving hyperglycaemia, liver enzymes and PD.

2.11 A Brief Report on Familial Dyslipidaemia

Dyslipidemia is the commonest complication of prediabetes and DM, and it predisposes to premature atherosclerosis; causing cardiovascular and cerebrovascular complications (Lalitha, Anjaneya, & Pradeep, 2013). Prediabetes precedes DM, and it is associated with cardiovascular complications (Ogbu et al., 2013), and dyslipidaemia is a major risk factor for the development of CVD (Oguejiofor, Onwukwe, & Odenigbo, 2012; Okaka & Eiya, 2013). Individuals with prediabetes have multiple disturbances in lipoprotein metabolism resulting from various factors inclusive of insulin deficiency, insulin resistance, and hyperglycaemia (Garber et al., 2008). CVD remains the leading cause of mortality in Nigeria (WHO, 2011), but screening for prediabetes and CVDs is yet to receive sufficient attention, perhaps due to lack of accessibility, affordability, awareness or poor attitude towards screening.

Information on the genetic predisposition of dyslipidaemia and prediabetes will lead to increased understanding of these metabolic disorders. Elsewhere, a meta-analysis of 46 lipid genome-wide association studies comprising >100 000 individuals of European ancestry established comprehensive genetic profiles for various blood lipids, including LDL-C, HDL-C and Triglycerides (Qi, Liang, Doria, Hu, & Qi, 2012).
2.12 Lifestyle Modification Advice: Aspects of Socioeconomic and Socio-cultural Factors

Prevalence of T2DM and associated co-morbidities are increasing globally and both prediabetes and MetS are associated with increased risk for CVD (Ford, Zhao, & Li, 2010; Mottillo et al., 2010). Epidemiological evidence suggests that without effective prevention and control measures, the prevalence of DM continues to increase (Alberti, Zimmet, & Shaw, 2007; Tuomilehto & Schwarz, 2010). Evidence from several studies showed that through lifestyle intervention, a considerable reduction in T2DM incidence is possible (Kosaka, Noda, & Kuzuya, 2005; Lindström et al., 2006; Tuomilehto et al., 2001). Understanding the interaction between socioeconomic and socio-cultural factors will provide insight for improving DM control through lifestyle advice (Funakoshi et al., 2017). These factors are presumed to be associated with diabetes control and overall health outcomes (Gonzalez-Zacarias, Mavarez-Martinez, Arias-Morales, Stoicea, & Rogers, 2016; Walker, Gebregziabher, Martin-Harris, & Egede, 2014).

Regulation of diet, increased physical activity and exercise are key components of control/management of T2DM (Alouki, Delisle, Bermúdez-Tamayo, & Johri, 2016; Boulé, Haddad, Kenny, Wells, & Sigal, 2001; Colberg et al., 2016). Current guidelines recommend lifestyle changes for both prevention and management of T2DM (ADA, 2013b). Lifestyle modification as it relates to diet, physical activity/exercise, salt consumption, loss of weight formed the socioeconomic and socio-cultural aspects of this study. Lifestyle change is perhaps not fully utilised in
Nigeria, yet constitutes a driving force in combating the rising prevalence of metabolic diseases.

2.13 Community Diabetes Screening in Nigeria

The number of individuals with DM has sharply increased globally over the last three decades, and making the disease an important public health threat (Chen, Magliano, & Zimmet, 2012). The pattern of prevalence of DM seems dependent on level of socioeconomic development, since the prevalence of DM has been increasing in LMICs at a rate higher than in high-income countries (WHO, 2016). There have been significant epidemiological changes in the occurrence of T2DM over the years, especially its relative rarity in developing countries some decades ago (Simmons, Williams, & Powell, 1989). It is reported that 80% of T2DM reside in less developed communities (Shaw et al., 2010). The prevalence of DM in Nigerian rural areas is between 0% – 2% of the rural population, and 5% – 10% in the urban (Enang et al., 2014; Nyenwe et al., 2003; Olatunbosun et al., 1998; Sabir et al., 2013), hence the need for early screening for the condition.

There have been opinions for the application of information criterion to obtain optimal choice between models (Akaike, 1974; Burnham & Anderson, 2004; Ewing et al., 2006). Amongst the available options, Akaike information criterion (AIC) has received special attention (Luypaert, Ingrisch, Sourbron, & de Mey, 2012). The AIC is a measure of relative quality of statistical models for a given dataset, and is used to determine the best model fit (Akaike, 1974). Series of models must be compared for the AIC to become useful, and the model with the lowest AIC is considered the
best. Estimation of effect of AIC, and its precision are important aspects of modelling, and not declaration of significance (Mazerolle, 2004). The AIC offers relative estimate of the information lost, when a given model is used to represent the process that generates the data. It takes into account the trade-off between goodness of fit of a statistical model and the complexity of the model (Carstens, Stoute, & Reid, 2009).

2.14 Conclusion

Diabetes and orodental diseases prevalence rates in Nigeria are high as reviewed, but data are lacking to rationalise co-morbidity of both diseases. The occurrence of both diseases involves pathogenic and pathological mechanisms. Inflammation has been implicated in the interaction of both diseases. T2DM, which is the focus of this review, is linked to elevated levels of system biomarkers of inflammation that trigger immunological responses. Many people are still undiagnosed with DM, and there is need for early detection and intervention to avert DM complications. The interaction of these diseases favours creation of avenues to establish opportunistic screening for DM in dental clinics. Data on cost-effectiveness of diabetes screening is critical, as it helps to provide information on feasibility of intervention through opportunistic screening. The relationship of (MetS and PD) and (hyperglycaemia, liver enzymes & PD) can constitute tools for detection of the conditions, especially diabetes and PD. In the epidemiological study of metabolic diseases in Nigeria, family history of dyslipidaemia is indispensable, as it concerns DM and PD. While the prevalence of DM in Nigeria remains a major concern, lifestyle that
encourages diabetes control is an option to consider. In rural communities with poor resources for diabetes control such as FBG screening, affordable alternatives that include use of anthropometric parameters for prediction of DM need to be explored.
CHAPTER 3: MATERIALS AND METHODS

3.1 Ethical Considerations

Ethical clearance for the study included Human Research Ethics Committee (HREC) of Charles Sturt University (CSU) approval (protocol number: 2015/286) (Appendix V). Prior to this, Ndokwa West Local Ministry of Health Department (for Kwale community) and EBGH gave approval for the parent research work (PACCS group) (Appendix V1). Other ethical considerations involved contractual memorandum of understanding between Catholic Hospital Abbi (CHA) and Global Medical Research & Development Organisation (GMRDO, who anchor the activities of the PACCS group in Nigeria) for data collection in Abbi community. Part of the ethic’s concerns was collaboration involving Novena University (Nigeria) Honours students and their supervisor, Dr Kester Digban, and these students were provided approval by Novena University to collaborate in this work. It also involved partnership with Delta State University (Nigeria) Honours students and their supervisor, Dr Efehire Aganbi.

3.2 Study Area and Selection of Participants

The study was undertaken in Abbi and Kwale communities, which are in Ndokwa West LGA. EBGH was another setting for the study, and these study locations are in Delta State of Nigeria (Figure 1.1). The choice of the two study settings stemmed from previous reports/gaps in knowledge among the residents of the former, and accessibility as well as infrastructural credibility of the later. Ndokwa residents have been
reported to show poor health seeking behaviour (Oguoma et al., 2014). 
EBGH is situated 27 Km from Ndokwa, and has ultra-modern dental clinic 
(FlashPointNews, 2014), hence was used for orodental examination aspect of the study. The two study areas are discussed below.

3.2.1 Study Area

3.2.1.1 Ndokwa Communities

Ndokwa communities are in Ndokwa West LGA as shown in Figure 1.1(a) (map of Delta State). Ndokwa West LGA covers 816 Km², and has a population of 149 325 (Anon, 2016; NPC, 2010). There is a standard hospital (CHA) that services Abbi residents as well as other communities, and renders medical services for minor health problems. However, this hospital does not provide services for serious orodental health care needs, and referrals are made to Specialist hospitals.

3.2.1.2 Eku Baptist Government Hospital

Eku Baptist Government Hospital (EBGH) is in Ethiope East LGA, and situated in Eku, a town in Delta State. It lies between geographical coordinates of 5.7361° N and 5.9356° E (GPS, 2017). It is 27 Km from Ndokwa, and services Abbi and Kwale residents; implying that the residents cover long distances for orodental visit. However, there is no better alternative dental clinic to EBGH. In addition, EBGH facility recently gained 5 years full accreditation for Family Medicine Training from the National Postgraduate Medical College of Nigeria and the West African College of Physicians (FlashPointNews, 2014).
3.2.2 Selection Criteria for Participants

**Inclusion:** Subjects who were 18 years and above, including males and females residing in Abbi and Kwale communities were recruited. Participation was voluntary, and the study ensured subjects were allowed at least one hour to read, and understand the information sheet (Appendix I) at the study centres. They were also encouraged to ask questions before signing the consent form (Appendix II) for enrolment.

**Exclusion:** Subjects who were pregnant before and during the screening exercise were excluded to avoid miss-classification of gestational DM as T2DM or DM in general. Further exclusion of pregnant women eliminates contradictions in evaluating obesity indices such as BMI. Hormonal changes in pregnancy influence glucose metabolism, and the level of periodontal inflammation (Lalla et al., 2011). Known diabetics, patients on anticoagulation therapy and those requiring antibiotic prophylaxis before a dental procedure were also excluded to avoid contradiction of results (Andriankaja & Joshipura, 2014). Individuals with systemic disease such as cancer and bleeding tendencies that contraindicate periodontal probing, were not enrolled (Wang et al., 2009).

3.3 Information Session

Awareness campaign and public lectures about the research preceded the data collection. These were organised, and carried out in market places, schools, churches and hospitals in Ndokwa communities. Fliers were also used in the dissemination of information about the research at the two study settings. Before data collection, information sheets and consent
forms were made available, so that potential participants were informed of the study, thus allowing informed consent to enrol in the study.

3.4 Determination of Sample Size

The community-based sample size was 400 as indicated in PACCS (Nwose et al., 2013), and the study was an integral part of PACCS. The PACCS proposed to screen a sample size of 2 000 of both genders over 5 years, and this translates to the 400 per year as specified above (Nwose et al., 2013). The study carried out community-based surveys, involving probability sampling of 10 and 15 streets from Abbi and Kwale communities, respectively. This was narrowed to random selection of 3 adults per home to achieve the desired sample size. The project integrated into PACCS through the involvement of prediabetes/undiagnosed diabetes, CVD and MetS aspects of the study. The StalCalc application of Epi-Info software (version 7.1, CDC Atlanta USA) was used in determining the population size at EBGH. An estimated 120 clients were proposed to be sampled at the dental clinic of EBGH, based on statistical significance and the number of in-patients and out-patients of the clinic per year. However, 433 participants and 41 clients were enrolled in Ndokwa communities and EBGH, respectively. There was poor dental visit by clients, hence the reduction in number of subjects sampled at the dental clinic.

The extra 33 participants sampled in Ndokwa communities were to increase the chance of recruiting individuals with ODI, and subsequently making more referrals to the dental clinic of EBGH for confirmation of their
orodental health status. This was because, it was realised in the course of the study that previous referrals to EBGH failed to attend the dental clinic.

3.5 Study Procedure

3.5.1 Overview of Methodology

The study enrolled 474 participants, including 433 community-based and 41 dental clinic-based. Participants were instructed to fast overnight for at least 8 hours before blood collection as recommended by American Diabetes Association (ADA, 2015). The subjects were recruited between 08:00 and 10:00 hours, and the exercise lasted from December 2015 to March 2016. The study was mindful of the fact that after a given time (prolonged fasting), the body starts compensating for hypoglycaemia through pathways such as gluconeogenesis, glycogenolysis etc (Rodwell, Bender, Botham, Kennelly, & Weil, 2015). Again, the study considered that the participants needed to go to their various activities/businesses. After enrolment, participant completed questionnaire(s) in preparation for anthropometric measurements. Biochemical tests preceded anthropometry, and this was followed by periodontal examination.

The questionnaire administration (as detailed in section 3.5.2), anthropometry and biochemical measurements were carried out in both study settings but the periodontal examination only occurred at the dental clinic of EGBH. Participants identified to show indication of orodental disease through questionnaire responses were referred to the dental clinic for periodontal examination and attention.
3.5.2 Research Questionnaire

This study involved the use of two questionnaires in both settings: (a) WHO STEPwise approach on non-communicable disease risk factor surveillance (STEPS) questionnaire (Appendix IV) for chronic diseases and health promotion (WHO, 2017) and (b) supplementary questionnaire (Appendix V). The WHO and supplementary questionnaires addressed information on demographics. However, the WHO questionnaire further elicited information on the number of people aged 18 years and above in the household as well as average income of respondents. It also asked questions on history of (BP, diabetes, raised cholesterol and CVD), lifestyle advice; physical measurements and orodental health. The supplementary questionnaire sought information on routine (biochemistry and hematology), periodontal examination as well as questions on history of laboratory test/diagnosis. Both contained questions on aspects of behavioural, socioeconomic and socio-cultural variables. The two questionnaires were hard-copy, and self-administered and those who could not complete the questionnaires were assisted; and this included a facility for face-to-face questionnaire administration/translation to local language. Both questionnaires were prior evaluated in a trial run for clarity.

3.5.3 Anthropometry and Materials Used in Measurements

The materials used in anthropometric measurements were weighing scale (Hana®, India), stadiometer (Seca® 213, United States of America [USA]), ergonometric circumference measuring tape (Seca® 203, USA) and Omron® automatic BP monitor (Australia). Waist and hip circumferences
were taken using ergonometric tape. Weight (Kg) and height (cm) were measured using the weighing scale and stadiometer, respectively. The weighing scale and stadiometer were placed on a hard, levelled floor to ensure accuracy. Measurement of WC (cm) was made at mid-point between the lower margin of the last palpable rib and the top of the iliac crest. The HC (cm) was taken around the widest portion of the buttocks as recommended by IDF (IDF, 2006).

Guidelines described by WHO to ensure the accuracy of these measurements were followed and recommendations for cut-offs for WC and WHR were adopted (WHO, 2008). The BMI was calculated by dividing the weight with height squared (Kg/m²). The systolic BP and diastolic BP (mmHg) were measured three consecutive times, and the average of the 2nd and 3rd readings taken, while the 1st reading was discarded. These measurements were taken by the principal investigator with the assistance of Honours students who were trained, and supervised by the principal investigator during the measurements.

3.5.3.1 Definitions of Anthropometric Parameters

Obesity was defined as WC: >94 cm (men) and >80 cm (women), based on threshold for sub-Saharan ethnicity described by the Joint Scientific Statement on Harmonizing the Metabolic Syndrome (Alberti et al., 2009). The waist-hip ratio cut-off value for men was ≥0.90 cm and ≥0.85 cm for women (IDF, 2006). The BMI was categorised as normal (18.5 – 24.9 Kg/m²), overweight (25.0 – 29.9 Kg/m²) and obese (≥30 Kg/m²) (Alberti et al., 2009).
Classification of MetS was based on the National Cholesterol Education Program-Adult Treatment Panel (NCEP ATP III) guidelines (Grundy, Brewer, Cleeman, Smith, & Lenfant, 2004), and is summarised in Table 3.1. Following the Joint International Summit on harmonisation of MetS in 2009, the condition was diagnosed when three of the five features presented (Alberti et al., 2009).

**Table 3.1: ATP III Clinical Identification of Metabolic Syndrome**

<table>
<thead>
<tr>
<th>Risk Factor</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abdominal obesity (waist circumference):</td>
<td></td>
</tr>
<tr>
<td>Men</td>
<td>&gt;102 cm</td>
</tr>
<tr>
<td>Women</td>
<td>&gt;88 cm</td>
</tr>
<tr>
<td>Triglyceride</td>
<td>≥1.69 mmol/L (≥150 mg/dL)</td>
</tr>
<tr>
<td>HDL cholesterol:</td>
<td></td>
</tr>
<tr>
<td>Men</td>
<td>&lt;1.03 mmol/L (&lt;40 mg/dL)</td>
</tr>
<tr>
<td>Women</td>
<td>&lt;1.29 mmol/L (&lt;50 mg/dL)</td>
</tr>
<tr>
<td>Blood pressure</td>
<td>≥135/≥85 mmHg</td>
</tr>
<tr>
<td>Fasting glucose</td>
<td>≥5.6 mmol/L (≥100 mg/dL)</td>
</tr>
</tbody>
</table>

**Key:** HDL cholesterol = high density lipoprotein cholesterol

3.5.4 Biochemical Measurements

The CardioChek® Professional Point of Care Diagnostic Analyser (Polymer Technology Systems, Inc, USA), Accu-Chek® Point of Care Diagnostic Analyser (Roche Diagnostics, United Kingdom [UK]) were used according to manufacturers’ instructions for measuring blood glucose and lipids, respectively. Gentle finger pricking with the lancet was performed, and blood flowed freely into a capillary tube (for lipid profile), and fluoride
tubes (for FBG test). RBS was collected from the dental patients after FBG test, specifically for modelling study (section 4.8 of Chapter 4). The blood was then applied to the panel of the Cardiochek and Accu-Chek, using the plunger; according to the manufacturer’s instructions. In addition to carrying out FBG and RBS tests, lipid profile tests such as TC, HDL-C and triglyceride were performed. The pictures of the Cardiochek and Accu-Chek are shown in Figures 3.1 and 3.2, respectively.

![Cardiochek](image1.png)  
**Figure 3.1:** Showing cardiochek professional point of care diagnostic analyser

![Accu-Chek](image2.png)  
**Figure 3.2:** Accu-Chek point of care diagnostic analyser
3.5.4.1 Criteria for Diabetes Mellitus

The criteria for diagnosing DM was \( \geq 7.0 \) mmol/L (\( \geq 126 \) mg/dL) (fasting plasma glucose) or random glucose (>11.1 mmol/L) (>200 mg/dL) and prediabetes was defined as impaired fasting glucose (IFG) level of 5.6 to <6.9 mmol/L (100 to <126 mg/dL) (ADA, 2013a, 2015). IFG (fasting capillary whole blood) was defined as 6.1 – 6.9 mmol/L (WHO, 2006). The parameters measured for lipid profile were blood levels of HDL-C, TC and triglyceride. Criteria for definition of dyslipidaemia were according to the National Cholesterol Education Program/Adult Treatment Panel III, and adopted (Table 3.2). Dyslipidaemia was defined as consisting of the following abnormalities either singly or in combination: blood levels of TC >5.17 mmol/L (200 mg/dL), HDL-C <1.03 mmol/L (<40 mg/dL) for males; <1.03 mmol/L (<50 mg/dL) for females and blood levels of TG >1.7 mmol/L (>150 mg/dL) (Cleeman, 2001).

**Table 3.2: National Cholesterol Education Program/Adult Treatment Panel III Lipid Parameters**

<table>
<thead>
<tr>
<th>Lipid Parameter</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>TC</td>
<td>&lt;5.2 mmol/L (&lt;200 mg/dL) normal, and ( \geq 5.2 ) mmol/L (( \geq 200 ) mg/dL) abnormal.</td>
</tr>
<tr>
<td><strong>Hypercholesterolaemia</strong></td>
<td>TC: ( \geq 5.2 ) mmol/L (( \geq 200 ) mg/dL)</td>
</tr>
<tr>
<td>HDL-C</td>
<td>&lt;1.0 mmol/L (&lt;40 mg/dL) low and &gt;1.6 mmol/L (&gt;60 mg/dL) high.</td>
</tr>
<tr>
<td><strong>HDL-C</strong></td>
<td>HDL-C: 1.0 mmol/L (( \leq 40 ) mg/dL) in males and 1.3 mmol/L (( \leq 50 ) mg/dL) in females defined as abnormal.</td>
</tr>
<tr>
<td>Triglyceride</td>
<td>&lt;3.9 mmol/L (&lt;150 mg/dL) normal, and ( \geq 3.9 ) mmol/L (( \geq 150 ) mg/dL) abnormal.</td>
</tr>
<tr>
<td><strong>Hypertriglyceridaemia</strong></td>
<td>TG: ( \geq 3.9 ) mmol/L (( \geq 150 ) mg/dL)</td>
</tr>
</tbody>
</table>

**Key:** TC = Total cholesterol, HDL-C = High density lipoprotein cholesterol
3.5.5 Periodontal Examination and Materials Used

Two types of PD data were collected; survey data collected in Ndokwa communities as well as EGBH and clinical examination data generated at the dental clinic. The nature of the survey data collected from participants who showed indication of orodental disease, informed referral to the dental clinic for clinical examination and confirmation. These are explained in details below.

3.5.5.1: Survey Questionnaire Data

The WHO STEPS questionnaire contained questions on presence or absence of pathological problems in the mouth/tooth of the participants. The ODI questions involved pain/discomfort, sleep interruption and feeling tensed due to state of the teeth/mouth. Other ODI questions required description of the state of the gum/teeth and difficulty experienced in biting/chewing food (Appendix IV). Information on dental clinic visit by respondents should have formed a core ODI, but was not included since the response to the question on dental clinic visit was poor, probably because of affordability of dental visit and/or poor health-seeking behaviour.

3.5.5.2 Clinical Examination Data

Periodontal examination was undertaken by a dentist, and indices such as BOP, CAL and GR were measured using periodontal probe; and mouth mirror was used to examine the mouth and teeth for cavities or tissue abnormalities. Detection of developing periodontal pockets was aided with the use of periodontal probe to measure depth of gingival crevices/periodontal pockets, and the probing force was not allowed to
exceed 20 g (Andriankaja & Joshipura, 2014). The periodontal probe detected calculus and measured furcation involvements. The periodontal examination involved FMA to determine periodontal status. In addition to visual examination, periodontal probe also detected sub-gingival plaque, sulcular depth and gingival attachment loss. The presence/absence of gingivitis, attrition, calculus and stains was noted. Presence of PD was confirmed based on Community Periodontal Index for Treatment Needs (CPITN) for pocket depth (Cutress, Ainamo, & Sardö-Infirri, 1987). PD results from the extension of the gingival inflammation into the underlying supporting structures of the periodontium, and initiated by the presence of plaque and its products on the surfaces of the teeth and the adjoining structures (Daniel, Gokulanathan, Shanmugasundaram, Lakshmigandhan, & Kavin, 2012).

**BOP:** Modifications of the methods of Lang, Adler, Joss, and Nyman (1990) and (Chaves et al., 1993) were adopted in measuring BOP. During periodontal probing, the probe was gently inserted to the base of the sulcus or pocket. The probing force was well regulated, and BOP was positive when the probed site bled within 20 seconds after removal of the probe tip (Andriankaja & Joshipura, 2014). After probing, buccal and mediobuccal sites were examined for the presence or absence of bleeding. This was grouped as: (i) no bleeding (ii) only one bleeding point appearing (iii) several isolated bleeding points or a small blood area appearing (iv) interdental triangle filled with blood soon after probing (v) profuse bleeding when probing, blood spreads towards the marginal gingiva. Studies have
shown that absence of BOP can function as predictor of periodontal stability (Lang et al., 1990).

**CAL:** The severity of periodontitis was based on the amount of CAL, and is categorised as slight (1-2 mm CAL), moderate (3-4 mm CAL) or severe (>5 mm CAL) (Wiebe & Putnins, 2000). Clinical presentation of CAL was by total denudation of the root surface of the tooth, and computed as the difference in millimeters between the measure of periodontal depth and GR (Andriankaja & Joshipura, 2014).

**FMA:** This was conducted to ascertain periodontal status of the patients, and the examination included presence/absence of gingivitis, attrition, calculus and stains. PD results from extension of gingival inflammation into underlying supporting structures of periodontium, and initiated by the presence of plaque and its products on surfaces of teeth and adjoining structures (Daniel et al., 2012).

**GR:** Calculated as the distance in millimeters between the free gingival margin (FGM) and the line of the cement-enamel junction (CEJ), Andriankaja and Joshipura (2014) allowed classification into 4, based on severity: (class I) gingival not up to mucogingival junction, (class II) recession beyond mucogingival junction, without attachment loss, (class III) recession beyond mucogingival junction, without periodontal loss; (class IV) recession beyond mucogingival junction, with bone loss. However, GR of 1-2 mm was (class I), 3 and 4 mm were (class II); while GR above 4 mm and 5 mm were either (class III or IV), depending on the type of tissue loss.
Modification of the method of Kumar and Masamatti (2013) was adopted in classification of GR.

3.6 Data Analysis

3.6.1 Groupings in the Study

Participants were grouped in various ways depending on the statistics performed. In this subsection, grouping of participants will be in relation to the discussion section in Chapter 4. The discussions will be numbered 1 – 8 in Chapter 5 for easy reading.

➢ In discussion 1, participants were grouped, based on FBG levels: normal, prediabetes and diabetes (hyperglycaemia). Blood lipid levels and anthropometric parameters such as age, height, HC, WC and WHR were then expressed descriptively, based on the grouping.

➢ Second discussion (2), grouping involved glycaemic status and (ODI and orodental clinical indices) as thus: hyperglycaemia + ODI; normoglycaemia + non-ODI, normoglycaemia + ODI and hyperglycaemia + non-ODI. Further grouping of hyperglycaemia was with each of the following: BOP, CAL, FMA and GR.

➢ In discussion 3, participants in Ndokwa communities were grouped into normoglycaemia, prediabetes and diabetes (hyperglycaemia). Those with hyperglycaemia were used to match with the previously identified diabetes subjects in the PACCS to determine the incidence rate of the disease. This was done to determine cost-effectiveness of community DM screening.
Discussion 4, grouping was not performed, instead; correlation analysis was carried out, based on BMI, FBG and lipid profile in relation with ODI scores.

Discussion 5 involves triangular relationship between hyperglycaemia, liver function and periodontitis. The subjects were placed in four groups, namely: prediabetes, prediabetes + PD, DM + PD, apparently healthy individuals.

No groupings were observed in discussion 6, as the analyses performed to generate the discussion required ungrouped data. This involved few people – extended family members of case study.

Discussion 7 required grouping of participants into normoglycaemia and hyperglycaemia.

Discussion 8, the subjects were separated into normal, prediabetes and diabetes.

3.6.2 Statistical Analysis Performed

The research produced qualitative and quantitative data, from which statistical analyses were carried out; leading to data presentation in Tables and Figures. The statistical packages used were IDM-Statistical Package for Social Sciences (IDM-SPSS) 20 and Microsoft Excel 2010 softwares. The statistics performed to generate the discussions in Chapter 4 are discussed below.
**Discussion 1:** Mean ± standard deviation (SD) of the parameters was calculated. Differences in mean values of age, biochemical and anthropometric variables between gender and glycaemic status were assessed using Man-Witney U test and Kruskal Wallis H test, respectively. These are non-parametric tests used when assumption of normality is not met. Frequency of diabetes and orodental health risk indicators were analysed and the 95% CI generated based on 1 000 bootstrap resampling. These were cross-tabulated, each across gender and age group, and the results expressed as percentages.

**Discussion 2:** Data were analysed descriptively and expressed in percentages for categorical variables, while mean and SD were used to present summary statistics of continuous variables. The 95% CI of prevalence of hyperglycaemia and ODI was based on 1 000 bootstrap resampling. Pearson Chi-Square was employed to test statistical significant differences between hyperglycaemia and ODI.

**Discussion 3:** The incidence of DM in Ndokwa subpopulation was calculated, and the cost-effectiveness of population screening of DM determined. Determination of incidence rate was to identify the number of new individuals with DM. It was also used to estimate whether it was cost-effective to spend Nigerian naira (NGN 300) to screening every newly identified diabetic relative to the population of Ndokwa communities (149 325). The indicated amount of money above (NGN 300) is the cost of FBG test in a not-for-profit hospital, as observed during this study; but costlier in private health facilities.
Calculation of incidence was given by the formula:

\[
\text{Incidence rate} = \frac{\text{Number of new cases of disease in a given period of time}}{\text{Sum of person-time at risk}}
\]

Incidence of prediabetes and UDM was calculated at 38.8% and 18.0%, respectively. Oguoma et al. (2015) determined the prevalence of prediabetes (4.9%) and diabetes (5.4%), and this formed the basis of the calculated incidence rate.

**Discussion 4:** Logistic regression was performed to determine the correlation of BMI, FBG and lipid profile with ODI score among individuals and subpopulation. The essence of the study between the two groups was to ascertain difference in correlation. The ODI scores were statistically derived from responses to ODI questions discussed in subsection 3.6.5.1, and as shown in Tables 3.3 and 3.4 below. In order to use variables with most appropriate responses, only responses in Tables 3.3 and 3.4 were used in the determination of ODI scores. Responses to the ODI questions were employed in the analysis of indices used to predict prediabetes, using AIC. Correlations of MetS and hyperglycaemia with orodental health involved the ODI.
Table 3.3: Points Awarded to ODI questions 1 – 3, 5 and 6 (Appendix III)

<table>
<thead>
<tr>
<th>ODI #</th>
<th>Codes</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Yes</td>
<td>No</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Don't know</td>
</tr>
<tr>
<td>2</td>
<td>No response/don't know</td>
<td>No</td>
<td>+</td>
<td>++</td>
<td>+++</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>No response/don't know</td>
<td>No</td>
<td>+</td>
<td>++</td>
<td>+++</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>No response/don't know</td>
<td>No</td>
<td>+</td>
<td>++</td>
<td>+++</td>
<td>Poor</td>
<td>Very poor</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>No response/don't know</td>
<td>No</td>
<td>+</td>
<td>++</td>
<td>+++</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 3.4: Points Awarded to ODI Questions 4 & 7 (Appendix III)

<table>
<thead>
<tr>
<th>ODI- 4 &amp; 7</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent</td>
<td>1</td>
</tr>
<tr>
<td>Very good &amp; good</td>
<td>2</td>
</tr>
<tr>
<td>Average</td>
<td>3</td>
</tr>
<tr>
<td>Poor &amp; very poor</td>
<td>4</td>
</tr>
</tbody>
</table>

**Key:** N = 385 with BMI for triangular relationship with FBG and ODI score

**Discussion 5:** The mean SD of the measured indices was determined. Results were considered significant at 95% confidence limit, multivariate analysis of variance (MANOVA) comparison was performed using Turkey HSD method. Correlation between blood glucose levels, liver markers and PD nexus was carried out. Another correlation done was between glycaemia and periodontal indices.

**Discussion 6:** This involved presentation of frequency of FBG, lipid parameters and BP in cross-tabulation. The overall result was then
expressed as percentage. All individuals (family members of case report) identified as having CVD risk factors were also part of the community-based study.

**Discussion 7:** Frequency of diabetes and responses to lifestyle modification advice were analysed and 95% CI generated based on 1 000 bootstrap re-sampling. These were cross-tabulated in relation to age and gender, and Pearson Chi-Square was performed to determine significant differences. Information on lifestyle advice was generated from the subjects and included data on tobacco smoking, salt intake, vegetable/fruit consumption, fatty diets, exercise/physical activity and maintenance of healthy body weight. These subjects were grouped according to age, glycaemic status and gender in relation to lifestyle advice.

**Discussion 8:** Modelling of various anthropometric as well as biochemical variables and ODI score was performed. Only the prediabetes group was used in the modelling as per understanding that prediabetic state precedes frank DM. Different models numbering 4 125 were generated, and the top 400 were selected and sorted, based on the AIC value. This was carried out to select the best models for prediction of prediabetes.
CHAPTER 4: RESULTS

4.0 Preamble

This chapter on results has each section reflecting one of the eight subsections on statistics as presented in Chapter 3. The various sections are sequentially numbered as in Chapter 5 to maintain consistency as well as logical flow and the sections are:

1. Prevalence of hyperglycaemia and risk factors for orodental disease in Nigeria: implications for opportunistic screening

2. Association of hyperglycaemia and orodental health in Nigerian rural communities

3. Critical review of data: cost-effectiveness of community diabetes screening

4. Triangular relationship of metabolic syndrome and periodontal disease

5. Triangular relationship between hyperglycaemia, liver function and periodontitis

6. Prediabetes and cardiovascular complications screening in Nigeria: a family case presentation

7. Behavioural medicine: lifestyle modification advice to control metabolic diseases in a Nigerian rural population

8. Application of Akaike information criterion in public health (diabetes) screening in Nigerian rural communities
4.1 Prevalence of Hyperglycaemia and Risk Factors for Orodental Disease in Nigeria: Implications for Opportunistic Screening

Table 4.1.1 shows the descriptive statistics of the study population in relation to gender. Overall, higher mean values of age, FBG, blood levels of TC and HDL-C, WC and HC were observed in females than males, but only TC, HDL-C and WC were significant. However, male participants had higher mean value of blood triglyceride levels than the females; and this was significant (P<0.05). There were no significant differences (P>0.05) in age, FBG, triglyceride, HC and WHR across gender.

The mean values of age, FBG, blood concentrations of TC, HDL-C, and triglyceride, WC, HC and WHR for participants that presented at the dental clinic are also shown in Table 4.1.1. In the dental clinic cohort, females also showed higher mean values by comparison with males in most parameters, including age (P = 0.185), FBG (0.915); TC (P = 0.001), HDL-C (P = 0.010), WC (P = 0.027) and HC (P = <0.0001). However, the mean values of triglyceride (P = 0.500) and WHR (P = 0.526) were higher in males than females. Age, FBG, triglyceride and WHR were not significantly different (P>0.05) between both groups.
Table 4.1.1: Descriptive statistics of the study population based on gender

<table>
<thead>
<tr>
<th>Ndokwa</th>
<th>All population</th>
<th>Male</th>
<th>Female</th>
<th>U-test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>Mean±SD</td>
<td>N</td>
<td>Mean±SD</td>
</tr>
<tr>
<td>Age (years)</td>
<td>394</td>
<td>47.7±20.5</td>
<td>167</td>
<td>46.2±20.9</td>
</tr>
<tr>
<td>FBG (mmol/L) (mg/dL)</td>
<td>417</td>
<td>5.9±1.1 (106.3±19.8)</td>
<td>175</td>
<td>5.9±1.0 (106.3±18.0)</td>
</tr>
<tr>
<td>Blood TC (mmol/L) (mg/dL)</td>
<td>203</td>
<td>3.7±1.6 (144.5±61.7)</td>
<td>86</td>
<td>3.5±1.6 (134.5±61.3)</td>
</tr>
<tr>
<td>Blood HDL-C (mmol/L) (mg/dL)</td>
<td>203</td>
<td>1.1±0.5 (44.0±18.9)</td>
<td>86</td>
<td>1.0±0.4 (39.8±17.3)</td>
</tr>
<tr>
<td>Blood TG (mmol/L) (mg/dL)</td>
<td>202</td>
<td>1.4±0.7 (125.4±62.9)</td>
<td>86</td>
<td>1.4±0.8 (126.6±66.5)</td>
</tr>
<tr>
<td>WC (cm)</td>
<td>191</td>
<td>90.2±15.0</td>
<td>98</td>
<td>87.6±12.8</td>
</tr>
<tr>
<td>HC (cm)</td>
<td>187</td>
<td>100.0±12.2</td>
<td>94</td>
<td>99.7±10.1</td>
</tr>
<tr>
<td>WHR</td>
<td>187</td>
<td>0.9±0.2</td>
<td>94</td>
<td>0.9±0.08</td>
</tr>
<tr>
<td>Dental clinic</td>
<td>N</td>
<td>Mean±SD</td>
<td>N</td>
<td>Mean±SD</td>
</tr>
<tr>
<td>Age (years)</td>
<td>41</td>
<td>39.5±15.3</td>
<td>24</td>
<td>36.8±15.1</td>
</tr>
<tr>
<td>FBG (mmol/L) (mg/dL)</td>
<td>41</td>
<td>5.9±0.7 (106.3±12.7)</td>
<td>24</td>
<td>5.8±0.5 (104.5±9.0)</td>
</tr>
<tr>
<td>Blood TC (mmol/L) (mg/dL)</td>
<td>41</td>
<td>3.7±1.0 (144.5±39.1)</td>
<td>24</td>
<td>3.3±0.8 (127.7±29.3)</td>
</tr>
<tr>
<td>Blood HDL-C (mmol/L) (mg/dL)</td>
<td>41</td>
<td>1.2±0.4 (47.0±15.0)</td>
<td>24</td>
<td>1.1±0.4 (41.8±14.0)</td>
</tr>
<tr>
<td>Blood TG (mmol/L) (mg/dL)</td>
<td>41</td>
<td>1.3±0.7 (111.3±65.7)</td>
<td>24</td>
<td>0.2±0.8 (113.2±67.9)</td>
</tr>
<tr>
<td>WC (cm)</td>
<td>32</td>
<td>93.8±16.1</td>
<td>17</td>
<td>88.2±9.2</td>
</tr>
<tr>
<td>HC (cm)</td>
<td>32</td>
<td>103.0±15.7</td>
<td>17</td>
<td>95.7±16.5</td>
</tr>
<tr>
<td>WHR</td>
<td>32</td>
<td>0.9±0.3</td>
<td>17</td>
<td>1.0±0.4</td>
</tr>
</tbody>
</table>

The criterion for diagnosing DM was ≥7.0 mmol/L (≥126 mg/dL) and prediabetes was defined as IFG level of 5.6 to <6.9 mmol/L (100 to <126 mg/dL) (ADA, 2013a, 2015). Key: Data in bold highlight P-value ≤0.05; †Exact significance test; the significance level is 0.05; FBG = Fasting blood glucose; TC = total cholesterol; HDL-C = high density lipoprotein cholesterol; TG = triglyceride; WC = waist circumference; HC = hip circumference; WHR = waist-to-hip ratio, U-test = Mann-Whitney U test, N = 474
The descriptive statistics of the study population on glycaemic status are shown in Table 4.1.2. The mean values of blood concentration of TC, HDL-C, and triglyceride, WC, HC and WHR were significantly higher in diabetics than in prediabetics: age (P = 0.002), triglyceride (P = 0.005), WC (P = 0.003) and HC (P = 0.007). No significant differences were observed in other parameters such as TC (P = 0.118) and HDL-C (P = 0.043) with respect to FBG status.

The mean values of age, TC, HDL-C, triglyceride, WC, HC and WHR of the subjects screened at the dental clinic are also presented in Table 4.1.2, which shows that majority of the indices measured were higher in diabetic subjects than in prediabetic individuals. However, WC (P = 0.976) and WHR (P = 0.496) mean values were higher in prediabetics than diabetics. There was significant difference in the age (P = 0.034) of both groups, and the mean age of the diabetics was higher by an average of 22.9 years, when compared with prediabetes (Table 4.1.2).
Table 4.1.2: Descriptive statistics of the study population based on glycaemic status

<table>
<thead>
<tr>
<th>Ndokwa</th>
<th>Normal</th>
<th>Prediabetes</th>
<th>Diabetes</th>
<th>H-test</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>Mean±SD</td>
<td>N</td>
<td>Mean±SD</td>
</tr>
<tr>
<td>Age (years)</td>
<td>160</td>
<td>50.3±21.8</td>
<td>156</td>
<td>43.2±19.6</td>
</tr>
<tr>
<td>Blood TC (mmol/L) (mg/dL)</td>
<td>44</td>
<td>3.7±1.2 (142.1±47.0)</td>
<td>110</td>
<td>3.5±1.4 (136.6±52.8)</td>
</tr>
<tr>
<td>Blood HDL-C (mmol/L) (mg/dL)</td>
<td>44</td>
<td>1.2±0.5 (48.2±20.5)</td>
<td>110</td>
<td>1.1±0.5 (41.4±18.2)</td>
</tr>
<tr>
<td>Blood Triglyceride (mmol/L) (mg/dL)</td>
<td>44</td>
<td>1.1±0.5 (100.8±47.8)</td>
<td>110</td>
<td>1.4±0.7 (125.5±64.5)</td>
</tr>
<tr>
<td>WC (cm)</td>
<td>51</td>
<td>85.8±13.4</td>
<td>89</td>
<td>90.1±15.6</td>
</tr>
<tr>
<td>HC (cm)</td>
<td>48</td>
<td>95.5±12.1</td>
<td>89</td>
<td>101.0±10.4</td>
</tr>
<tr>
<td>WHR</td>
<td>48</td>
<td>0.9±0.1</td>
<td>89</td>
<td>0.9±0.2</td>
</tr>
<tr>
<td>Dental clinic</td>
<td>N</td>
<td>Mean±SD</td>
<td>N</td>
<td>Mean±SD</td>
</tr>
<tr>
<td>Age (years)</td>
<td>15</td>
<td>37.9±14.9</td>
<td>22</td>
<td>36.9±14.1</td>
</tr>
<tr>
<td>Blood TC (mmol/L) (mg/dL)</td>
<td>15</td>
<td>3.7±1.0 (141.5±38.8)</td>
<td>22</td>
<td>3.7±1.1 (142.6±41.4)</td>
</tr>
<tr>
<td>Blood HDL-C (mmol/L) (mg/dL)</td>
<td>15</td>
<td>1.2±0.4 (46.1±16.5)</td>
<td>22</td>
<td>1.2±0.4 (46.9±14.4)</td>
</tr>
<tr>
<td>Blood Triglyceride (mmol/L) (mg/dL)</td>
<td>15</td>
<td>1.1±0.6 (97.9±55.7)</td>
<td>22</td>
<td>1.2±0.8 (110.7±67.3)</td>
</tr>
<tr>
<td>WC (cm)</td>
<td>12</td>
<td>93.1±14.8</td>
<td>18</td>
<td>94.6±18.1</td>
</tr>
<tr>
<td>HC (cm)</td>
<td>12</td>
<td>100.1±22.3</td>
<td>18</td>
<td>104.1±10.7</td>
</tr>
<tr>
<td>WHR</td>
<td>12</td>
<td>1.0±0.43</td>
<td>18</td>
<td>0.9±0.09</td>
</tr>
</tbody>
</table>

The criterion for diagnosing DM was ≥7.0 mmol/L (≥126 mg/dL) and prediabetes was defined as IFG level of 5.6 to <6.9 mmol/L (100 to <126 mg/dL) (ADA, 2013a, 2015). Key: Data in bold highlight P-value ≤0.05, the significance level is 0.05; TC= Total cholesterol; HDL-C = high density lipoprotein cholesterol; WC = waist circumference; HC = hip circumference; WHR = waist-to-hip ratio, H-test = Kruskal Wallis H test, N= 474
The glycaemic status of the study population is presented in Figure 4.1.1, which shows the prevalence of hyperglycaemia in the hospital-based study to be higher than in the community. However, prevalence of diabetes in Ndokwa communities was about twice compared to those observed at the dental clinic.

Key: The y-axis represents prevalence of glycaemic statuses in the community and dental clinic, while x-axis is showing glycaemic status of the study population.

Figure 4.1.1: Glycaemic status of the study population

Age and sex distribution of the participants in Ndokwa communities are shown in Figure 4.1.2. Highest prevalences of diabetes were observed in the age brackets 50 – 59 years, followed by 40 – 49 years; and the least was noted in the age group 18 – 29 years. Prevalence of prediabetes peaked in the age group 18 – 29 years, followed by 30 – 39 years; and the least was observed in those aged 70 years and above. With gender consideration, more females had DM than males, and vice versa for prediabetes (Figure 4.1.2).
Figure 4.1.2: Age and sex distribution of Ndokwa population in relation to glycaemic status

Tables 4.1.3a and b on frequency of orodental disease indicators in Ndokwa communities in the previous 12 months shows that of the total respondents (474), over a third had periodontitis, about a quarter reported experiencing pain or discomfort in the mouth and three quarters had not experienced interruption in their sleep due to the state of their teeth. The majority described the health of their teeth or mouth or gums as good and had not experienced difficulties in chewing or biting foods. Overall, 184 (42.5%) participants had ODI, and of these only 2 visited the dental clinic.
Table 4.1.3a: Frequency of orodental indicators in Ndokwa communities

During the past 12 months, did your teeth or mouth cause any pain or discomfort?

<table>
<thead>
<tr>
<th>Responses</th>
<th>Frequency</th>
<th>Prevalence (%)</th>
<th>(95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No answer</td>
<td>15</td>
<td>3.2</td>
<td>1.7 – 4.8</td>
</tr>
<tr>
<td>Yes</td>
<td>127</td>
<td>26.8</td>
<td>22.8 – 31.2</td>
</tr>
<tr>
<td>No</td>
<td>326</td>
<td>68.8</td>
<td>64.3 – 72.8</td>
</tr>
<tr>
<td>Don't know</td>
<td>5</td>
<td>1.1</td>
<td>0.2 – 2.1</td>
</tr>
</tbody>
</table>

Because of the state of your teeth or mouth, how often have you had sleep that is often interrupted during the past 12 months?

<table>
<thead>
<tr>
<th>Responses</th>
<th>Frequency</th>
<th>Prevalence (%)</th>
<th>(95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Don't know</td>
<td>29</td>
<td>6.1</td>
<td>4.0 – 8.2</td>
</tr>
<tr>
<td>No</td>
<td>351</td>
<td>74.1</td>
<td>70.3 – 78.3</td>
</tr>
<tr>
<td>Sometimes</td>
<td>44</td>
<td>9.3</td>
<td>6.8 – 12.0</td>
</tr>
<tr>
<td>Fairly often</td>
<td>14</td>
<td>3.0</td>
<td>1.5 – 4.4</td>
</tr>
<tr>
<td>Very often</td>
<td>4</td>
<td>0.8</td>
<td>0.2 – 1.7</td>
</tr>
</tbody>
</table>

Because of the state of your teeth or mouth, how often have you felt tense because of problems with teeth or mouth during the past 12 months?

<table>
<thead>
<tr>
<th>Responses</th>
<th>Frequency</th>
<th>Prevalence (%)</th>
<th>(95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Don't know</td>
<td>31</td>
<td>6.5</td>
<td>4.4 – 8.6</td>
</tr>
<tr>
<td>No</td>
<td>341</td>
<td>71.9</td>
<td>67.7 – 76.4</td>
</tr>
<tr>
<td>Sometimes</td>
<td>47</td>
<td>9.9</td>
<td>7.2 – 12.7</td>
</tr>
<tr>
<td>Fairly often</td>
<td>18</td>
<td>3.8</td>
<td>2.1 – 5.7</td>
</tr>
<tr>
<td>Very often</td>
<td>5</td>
<td>1.1</td>
<td>0.2 – 2.1</td>
</tr>
</tbody>
</table>

How would you describe the state of your teeth?

<table>
<thead>
<tr>
<th>Response</th>
<th>Frequency</th>
<th>Prevalence (%)</th>
<th>(95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent</td>
<td>134</td>
<td>28.3</td>
<td>24.3 – 32.1</td>
</tr>
<tr>
<td>Very good</td>
<td>90</td>
<td>19.0</td>
<td>15.6 – 22.8</td>
</tr>
<tr>
<td>Good</td>
<td>98</td>
<td>20.7</td>
<td>17.1 – 24.5</td>
</tr>
<tr>
<td>Average</td>
<td>94</td>
<td>19.8</td>
<td>16.2 – 23.4</td>
</tr>
<tr>
<td>Poor</td>
<td>32</td>
<td>6.8</td>
<td>4.9 – 9.1</td>
</tr>
<tr>
<td>Very poor</td>
<td>11</td>
<td>2.3</td>
<td>1.1 – 3.8</td>
</tr>
<tr>
<td>Don't know</td>
<td>14</td>
<td>3.0</td>
<td>1.5 – 4.6</td>
</tr>
</tbody>
</table>
Table 4.1.3b: Frequency of orodental disease indicators in Ndokwa communities

Because of the state of your teeth or mouth, how often have you experienced difficulty chewing foods during the past 12 months?

<table>
<thead>
<tr>
<th>Responses</th>
<th>Frequency</th>
<th>Prevalence</th>
<th>(95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Don't know</td>
<td>25</td>
<td>5.3</td>
<td>3.6 – 7.4</td>
</tr>
<tr>
<td>No</td>
<td>307</td>
<td>64.8</td>
<td>60.3 – 69.2</td>
</tr>
<tr>
<td>Sometimes</td>
<td>57</td>
<td>12.0</td>
<td>9.1 – 15.0</td>
</tr>
<tr>
<td>Fairly often</td>
<td>25</td>
<td>5.3</td>
<td>3.4 – 7.4</td>
</tr>
<tr>
<td>Very often</td>
<td>30</td>
<td>6.3</td>
<td>4.2 – 8.6</td>
</tr>
</tbody>
</table>

Because of the state of your teeth or mouth, how often have you experienced difficulty in biting foods during the past 12 months?

<table>
<thead>
<tr>
<th>Responses</th>
<th>Frequency</th>
<th>Prevalence</th>
<th>(95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Don't know</td>
<td>22</td>
<td>4.6</td>
<td>3.0 – 6.5</td>
</tr>
<tr>
<td>No</td>
<td>303</td>
<td>63.9</td>
<td>59.7 – 68.1</td>
</tr>
<tr>
<td>Sometimes</td>
<td>52</td>
<td>11.0</td>
<td>8.0 – 13.9</td>
</tr>
<tr>
<td>Fairly often</td>
<td>31</td>
<td>6.5</td>
<td>4.4 – 9.3</td>
</tr>
<tr>
<td>Very often</td>
<td>35</td>
<td>7.4</td>
<td>5.1 – 9.6</td>
</tr>
</tbody>
</table>

How would you describe the state of your gums?

| Excellent       | 121       | 25.5       | 21.5 – 29.5|
| Very good       | 106       | 22.4       | 18.8 – 26.2|
| Good            | 102       | 21.5       | 17.9 – 25.3|
| Average         | 86        | 18.1       | 14.8 – 21.5|
| Poor            | 35        | 7.4        | 5.1 – 9.9|
| Very poor       | 8         | 1.7        | 0.6 – 3.0|
| Don't know      | 15        | 3.2        | 1.7 – 4.6|

<table>
<thead>
<tr>
<th>Presence of orodental disease indicator</th>
<th>Frequency</th>
<th>Overall prevalence (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>184</td>
<td>42.5</td>
</tr>
<tr>
<td>No</td>
<td>249</td>
<td>57.5</td>
</tr>
<tr>
<td>Total</td>
<td>433</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Key: CI = confidence interval, N = 474
4.2 Association of Hyperglycaemia and Orodental Health in Nigerian Rural Communities

Anthropometric, orodental and biochemical characteristics of the study population are presented in Table 4.2.1, highlighting the mean and standard deviation/percentages of the measured parameters.

Table 4.2.1: Anthropometric, orodental and biochemical characteristics of the study population

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>N</th>
<th>Mean±SD/Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>472</td>
<td>46.3±19.9</td>
</tr>
<tr>
<td>BGL (mg/dL)</td>
<td>246/433</td>
<td>56.8%</td>
</tr>
<tr>
<td>HDL (mmol/L)</td>
<td>241</td>
<td>0.03±0.01</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(1.15±0.5)</td>
</tr>
<tr>
<td>Cholesterol (mmol/L)</td>
<td>242</td>
<td>0.10±0.04</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(3.74±1.5)</td>
</tr>
<tr>
<td>Triglyceride (mmol/L)</td>
<td>242</td>
<td>0.04±0.02</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(3.18±1.7)</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>405</td>
<td>65.4±16.5</td>
</tr>
<tr>
<td>WC (cm)</td>
<td>224</td>
<td>90.6±15.5</td>
</tr>
<tr>
<td>HC (cm)</td>
<td>224</td>
<td>100.3±13.0</td>
</tr>
<tr>
<td>WHR</td>
<td>224</td>
<td>0.9±0.2</td>
</tr>
<tr>
<td>BMI (Kg/m²)</td>
<td>398</td>
<td>25.3±6.2</td>
</tr>
<tr>
<td>ODI</td>
<td>206/474</td>
<td>43.5%</td>
</tr>
<tr>
<td>FMA</td>
<td>39/41</td>
<td>95.1%</td>
</tr>
<tr>
<td>BOP</td>
<td>39/41</td>
<td>95.1%</td>
</tr>
<tr>
<td>GR (mm)</td>
<td>39/41</td>
<td>95.1%</td>
</tr>
<tr>
<td>CAL (mm)</td>
<td>39/41</td>
<td>95.1%</td>
</tr>
<tr>
<td>PD</td>
<td>8/41</td>
<td>19.5%</td>
</tr>
</tbody>
</table>

Key: BGL = Blood glucose level, HDL = High density lipoprotein, WC = Waist circumference, HC = Hip circumference; WHR = Waist-hip ratio, BMI = Body mass index, ODI = Orodental disease indicator; FMA = Full mouth assessment, BOP = Bleeding on probing, GR = Gingival recession, CAL = Clinical attachment loss and PD = Periodontal disease, N = 474
The relationship of hyperglycaemia and ODI in the entire study population is summarised in Table 4.2.2. Subjects who had both hyperglycaemia and ODI were 74.7% (CI: 71.8 – 79.4). Individuals without hyperglycaemia, but with ODI were 18.8% (CI: 15.6 – 22.4). Hyperglycaemia subjects who were not positive for ODI were 34.0% (CI: 30.2 – 37.8) (Table 4.2.2).

**Table 4.2.2: Relationship of hyperglycaemia and orodental disease indicators**

<table>
<thead>
<tr>
<th>Hyperglycaemia vs. ODI</th>
<th>N</th>
<th>Proportion (n)/N</th>
<th>Prevalence (%)</th>
<th>(95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hyperglycaemia (+ve) + ODI (+ve)</td>
<td>457</td>
<td>111</td>
<td>24.3</td>
<td>20.1 – 28.4</td>
</tr>
<tr>
<td>Hyperglycaemia (-ve) + ODI (-ve)</td>
<td>457</td>
<td>346</td>
<td>75.7</td>
<td>71.8 – 79.4</td>
</tr>
<tr>
<td>Hyperglycaemia (-ve) + ODI (+ve)</td>
<td>473</td>
<td>89</td>
<td>18.8</td>
<td>15.6 – 22.4</td>
</tr>
<tr>
<td>Hyperglycaemia (+ve) + ODI (-ve)</td>
<td>473</td>
<td>161</td>
<td>34.0</td>
<td>30.2 – 37.8</td>
</tr>
</tbody>
</table>

ODI = Orodental disease indicator

The frequency of observations in periodontal examination at the dental clinic is shown in Table 4.2.3. Regarding FMA, 41% of the patients presented with pathology in their mouth, while nearly 60% of the participants maintained fair oral hygiene. BOP was observed in 71.8% and GR in 64.1% of the participants. However, 51.3% of the patients had moderate to severe CAL (Table 4.2.3).
Table 4.2.3: Frequency of observations in periodontal examination at the dental clinic

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Observation</th>
<th>Frequency</th>
<th>Prevalence (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>FMA</strong></td>
<td>Fair oral hygiene</td>
<td>23</td>
<td>59.0</td>
</tr>
<tr>
<td></td>
<td>Generalised stain</td>
<td>7</td>
<td>17.9</td>
</tr>
<tr>
<td></td>
<td>Chronic marginal gingivitis with mild gingival recession/attrition</td>
<td>8</td>
<td>20.5</td>
</tr>
<tr>
<td></td>
<td>Chronic marginal gingivitis with CAL/calculus/attrition</td>
<td>1</td>
<td>2.6</td>
</tr>
<tr>
<td><strong>BOP</strong></td>
<td>No bleeding</td>
<td>11</td>
<td>28.2</td>
</tr>
<tr>
<td></td>
<td>Only one bleeding point appearing</td>
<td>8</td>
<td>20.5</td>
</tr>
<tr>
<td></td>
<td>Several isolated bleeding points or a small blood area appearing</td>
<td>9</td>
<td>23.1</td>
</tr>
<tr>
<td></td>
<td>Interdental triangle filled with blood soon after probing</td>
<td>4</td>
<td>10.3</td>
</tr>
<tr>
<td></td>
<td>Profuse bleeding when probing, blood spreads towards the marginal gingiva</td>
<td>7</td>
<td>17.9</td>
</tr>
<tr>
<td><strong>GR (mm)</strong></td>
<td>1-2 mm (Gingival not up to the mucogingival junction)</td>
<td>1</td>
<td>2.6</td>
</tr>
<tr>
<td></td>
<td>3-4mm (Recession beyond the mucogingival junction, without attachment loss)</td>
<td>14</td>
<td>25.6</td>
</tr>
<tr>
<td></td>
<td>5mm (Recession beyond the mucogingival junction, without periodontal loss other than bone)</td>
<td>14</td>
<td>25.6</td>
</tr>
<tr>
<td></td>
<td>&gt;5mm (Recession beyond mucogingival junction with bone loss)</td>
<td>10</td>
<td>10.3</td>
</tr>
<tr>
<td><strong>CAL (mm)</strong></td>
<td>Slight (1 - 2 mm CAL)</td>
<td>19</td>
<td>48.7</td>
</tr>
<tr>
<td></td>
<td>Moderate (3 - 4 mm CAL)</td>
<td>15</td>
<td>38.5</td>
</tr>
<tr>
<td></td>
<td>Severe (&gt;5 mm CAL)</td>
<td>5</td>
<td>12.8</td>
</tr>
</tbody>
</table>

Key: BOP = Bleeding on probing, CAL = Clinical attachment loss, FMA = Full mouth assessment, GR = Gingival recession; N = 39
Table 4.2.4 shows the relationship of hyperglycaemia and clinical periodontal parameters at the dental clinic. Of noteworthy is that the highest prevalence of co-morbidity was observed in patients who presented with co-morbidity of (hyperglycaemia and CAL), followed by (hyperglycaemia and GR). The least prevalence of 21.3% was recorded in hyperglycaemia and FMA (Table 4.2.4).

Table 4.2.4: Association of hyperglycaemia with some clinical periodontal parameters at the dental clinic

<table>
<thead>
<tr>
<th>Co-morbidity</th>
<th>Proportion (n)/N</th>
<th>Prevalence (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hyperglycaemia + BOP</td>
<td>17</td>
<td>43.6</td>
</tr>
<tr>
<td>Hyperglycaemia + CAL (mm)</td>
<td>25</td>
<td>64.1</td>
</tr>
<tr>
<td>Hyperglycaemia + FMA</td>
<td>9</td>
<td>21.3</td>
</tr>
<tr>
<td>Hyperglycaemia + GR (mm)</td>
<td>24</td>
<td>61.5</td>
</tr>
</tbody>
</table>

Key: BOP = Bleeding on probing, CAL = Clinical attachment loss, FMA = Full mouth assessment, GR = Gingival recession, N = 39

4.3 Critical Review of Data

Table 4.3.1 is a simplified cost-effectiveness analysis of community-based diabetes screening. The incidence rates of prediabetes and UDM were 0.113% and 0.158%, respectively or 0.159% hyperglycaemia. The cost of identifying less than 2 persons with prediabetes or diabetes by screening a population of 1 000 is NGN 300 000. This serves as point of reference for not-for-profit hospitals and organisations considering mass screening.
Table 4.3.1: Simplified cost-effectiveness analysis

<table>
<thead>
<tr>
<th>Considerations</th>
<th>Glycaemic status</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Prediabetes (%)</td>
</tr>
<tr>
<td>Previous prevalence of hyperglycaemia</td>
<td>4.9</td>
</tr>
<tr>
<td>Prevalence rate relative to 433 people screened</td>
<td>38.8</td>
</tr>
<tr>
<td>Incidence rate relative to Ndokwa population</td>
<td>0.113</td>
</tr>
<tr>
<td>Cost of diabetes screening</td>
<td>NGN 300 000 in not-for-profit hospitals.</td>
</tr>
<tr>
<td>Cost of screening every 1 000 people</td>
<td>≥NGN 300 000 will be spent to identify &lt;2 persons with prediabetes or UDM</td>
</tr>
</tbody>
</table>

Key: UDM = Undiagnosed diabetes mellitus, N = 433. The figure (NGN 300) in Table 4.3.1 was highlighted in ‘Discussion 3’ in subsection 3.3.6.3 of Chapter 3.

4.4 Triangular Relationship of Metabolic Syndrome and Periodontal Disease

Table 4.4.1 shows the correlation of BMI, FBG and ODI scores in the entire study population. A critical observation shows that healthy, prediabetic and diabetic subpopulations exhibited high correlation than considered individually in a population of 385. Based on individuals, the least correlation was found between ODI scores and BMI. The least correlation, based on subpopulation was observed between ODI scores and FBG.
Table 4.4.1: Correlation of BMI, FBG and ODI scores in the entire study population

<table>
<thead>
<tr>
<th>Grouping</th>
<th>FBG</th>
<th>BMI</th>
<th>ODI scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>Based on individuals</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FBG</td>
<td>1.000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BMI</td>
<td>0.301</td>
<td>1.000</td>
<td></td>
</tr>
<tr>
<td>ODI scores</td>
<td>0.089</td>
<td>-0.034</td>
<td>1.000</td>
</tr>
<tr>
<td>Based on subpopulation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FBG</td>
<td>1.000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BMI</td>
<td>0.961</td>
<td>1.000</td>
<td></td>
</tr>
<tr>
<td>ODI scores</td>
<td>0.812</td>
<td>0.942</td>
<td>1.000</td>
</tr>
</tbody>
</table>

Key: FBG = Fasting blood glucose, BMI = Body mass index, ODI scores = Orodental disease indicator scores, N = 385

Correlations between FBG, blood concentrations of TC, HDL-C, and triglyceride and ODI scores in the overall study population are shown in Table 4.4.2. Association of the variables was stronger in subpopulations compared to weak correlation observed in individuals in the total population of 175.

Table 4.4.2: Correlation of lipid profile, FBG and ODI scores

<table>
<thead>
<tr>
<th></th>
<th>FBG</th>
<th>Blood TC</th>
<th>Blood HDL-C</th>
<th>Blood TG</th>
<th>ODI scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>Based on individuals</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FBG</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TC</td>
<td>0.058104</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HDL-C</td>
<td>-0.09284</td>
<td>0.516081</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TG</td>
<td>0.218908</td>
<td>-0.00834</td>
<td>-0.22459</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>ODI scores</td>
<td>-0.0191</td>
<td>0.025431</td>
<td>-0.01523</td>
<td>0.037103</td>
<td>1</td>
</tr>
<tr>
<td>Based on subpopulation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FBG</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TC</td>
<td>0.655355</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HDL-C</td>
<td>-0.47883</td>
<td>0.349304</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TG</td>
<td>0.973181</td>
<td>0.464023</td>
<td>-0.66794</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>ODI scores</td>
<td>-0.48172</td>
<td>-0.97761</td>
<td>-0.53867</td>
<td>-0.26721</td>
<td>1</td>
</tr>
</tbody>
</table>

Key: FBG = Fasting blood glucose, TC = Total cholesterol, HDL-C = High density lipoprotein cholesterol; TG = Triglyceride, ODI score = Orodental disease indicator score, N = 175

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4.5 Triangular Relationship Between Hyperglycaemia, Liver Function and Periodontitis

The triangular relationship between hyperglycaemia, liver markers and PD among the dental patients is indicated in Table 4.5.1. Average levels of CAL and GR as indices of PD as well as of liver markers indicated by blood levels of bilirubin and total protein and transaminases activities correlated well with FBG levels

Table 4.5.1: Correlation of FBG, liver markers and PD among dental patients

<table>
<thead>
<tr>
<th></th>
<th>FBG (mmol/L)</th>
<th>CAL (mm)</th>
<th>Mean GR (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>FBG (mmol/L)</td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CAL (mm)</td>
<td>0.74</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Mean GR (mm)</td>
<td>0.72</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Aspartate transaminase (IU/L)</td>
<td>0.17</td>
<td>0.61</td>
<td>0.65</td>
</tr>
<tr>
<td>Alanine transaminase (IU/L)</td>
<td>0.02</td>
<td>0.44</td>
<td>0.49</td>
</tr>
<tr>
<td>Alkaline phosphatase (IU/L)</td>
<td>-0.09</td>
<td>0.14</td>
<td>0.20</td>
</tr>
<tr>
<td>Total protein (g/L)</td>
<td>0.88</td>
<td>0.64</td>
<td>0.60</td>
</tr>
<tr>
<td>Albumin (g/L)</td>
<td>-0.15</td>
<td>-0.30</td>
<td>-0.34</td>
</tr>
<tr>
<td>Total bilirubin (µmol/L)</td>
<td>0.71</td>
<td>0.82</td>
<td>0.84</td>
</tr>
<tr>
<td>Direct bilirubin (µmol/L)</td>
<td>0.01</td>
<td>0.49</td>
<td>0.54</td>
</tr>
</tbody>
</table>

Key: FBG = Fasting blood glucose, CAL = Clinical attachment loss, GR = Gingival recession, N = 34

Figure 4.2 displays the interaction between FBG, CAL and GR among the dental patients, mean values of CAL and GR in groups show unidirectional increase from (non-PD + prediabetes) to (PD + prediabetes) and highest in (PD + DM), which was not observed in liver biomarkers.
Figure 4.2: Interaction of FBG, CAL and GR among dental patients

Figure 4.3 shows liver function tests parameters in relation to gender among dental patients. Overall, liver function parameters showed no significant difference between genders (P>0.05), except for the transaminases activities, which were higher in males compared to females (P<0.05).

Figure 4.3: Liver function tests in relation to gender among dental patients
4.6 Prediabetes and Cardiovascular Complications Screening in Nigeria: A Family Case Presentation

Table 4.6.1 is a family case presentation of metabolic disorders. The result indicated that ≈55% members of the family had up to two metabolic disorders or risk factors including dyslipidaemia that may predispose them to CVD. History of periodontitis in the family was also observed.

Table 4.6.1: Showing results of the screened family members

<table>
<thead>
<tr>
<th>Biochemical parameter</th>
<th>Number screened</th>
<th>Number positive</th>
<th>Relationship with Subject</th>
</tr>
</thead>
<tbody>
<tr>
<td>FBG</td>
<td>11</td>
<td>4</td>
<td>Mother, sister, nephew and niece</td>
</tr>
<tr>
<td>Blood TC</td>
<td>3</td>
<td>3</td>
<td>Mother, sister and niece</td>
</tr>
<tr>
<td>Blood HDL</td>
<td>6</td>
<td>6</td>
<td>Mother, 2 niece and 3 nephews</td>
</tr>
<tr>
<td>Blood Triglyceride</td>
<td></td>
<td>0</td>
<td>Mother, younger sister, nieces and nephews</td>
</tr>
<tr>
<td>BP</td>
<td></td>
<td>4</td>
<td>2 sisters and 2 nephews</td>
</tr>
</tbody>
</table>

It is pertinent to note that 6/11 (≈55%) family members had up to two metabolic disorders or risk factors including dyslipidaemia that may predispose them to CVD. There was also observation that the client’s younger sister showed indication of periodontitis, as she complained of periodontal pain during the screening. She was subsequently followed-up at the dental clinic of EBGH and periodontitis was confirmed.

Key: FBG = Fasting blood glucose, TC = Total cholesterol, HDL = High density lipoprotein; BP = Blood pressure
4.7 Behavioural Medicine: Lifestyle Modification Advice to Control Metabolic Diseases in a Nigerian Rural Population

Table 4.7.1 shows the gender-related distribution of lifestyle modification response. Overall, more females admitted being advised by healthcare practitioners to practice lifestyle modification to achieve control of metabolic diseases.

Table 4.7.1: Gender-related distribution of lifestyle modification response in rural communities

<table>
<thead>
<tr>
<th>Lifestyle response</th>
<th>Male</th>
<th>Female</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes (%)</td>
<td>No (%)</td>
<td>Yes (%)</td>
</tr>
<tr>
<td>Tobacco smoking</td>
<td>40 (23.0)</td>
<td>134 (77.0)</td>
<td>35 (14.8)</td>
</tr>
<tr>
<td>Salt intake</td>
<td>48 (27.6)</td>
<td>126 (72.4)</td>
<td>72 (30.4)</td>
</tr>
<tr>
<td>Vegetable and/or fruit consumption</td>
<td>55 (31.6)</td>
<td>119 (68.4)</td>
<td>84 (35.4)</td>
</tr>
<tr>
<td>Reduce fats in diet</td>
<td>42 (24.3)</td>
<td>131 (75.7)</td>
<td>61 (25.7)</td>
</tr>
<tr>
<td>Engage in physical activity</td>
<td>57 (32.8)</td>
<td>117 (67.2)</td>
<td>67 (28.3)</td>
</tr>
<tr>
<td>Maintain healthy body weight</td>
<td>48 (27.7)</td>
<td>125 (72.3)</td>
<td>65 (28.1)</td>
</tr>
</tbody>
</table>

Figure 4.4 is a representation of response to lifestyle modification and daily consumption of at least 5 servings of vegetable/fruit was the mostly advised lifestyle modification, and the least was quitting tobacco smoking.
**Figure 4.4: Response to lifestyle advice in rural communities**

Table 4.7.2 reflects the distribution of the participants based on age, education and marital status. More respondents (56.3%) were above 40 years of age. Most of the respondents had attained secondary school (25.1%), and only 2.9% had postgraduate degree. Majority of the subjects (50.7%) were married, whereas a few (1.5%) were separated (Table 4.7.2).
Table 4.7.2: Distribution according to age, education and marital status

<table>
<thead>
<tr>
<th>Variable (N = 418)</th>
<th>Frequency (%)</th>
<th>(95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;40 years</td>
<td>167 (43.7)</td>
<td>(38.7 – 49.0)</td>
</tr>
<tr>
<td>&gt;40 years</td>
<td>215 (56.3)</td>
<td>(51.0 – 61.3)</td>
</tr>
<tr>
<td>Education</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No formal schooling</td>
<td>88 (21.0)</td>
<td>(15.8 – 26.0)</td>
</tr>
<tr>
<td>Less than primary school</td>
<td>26 (6.2)</td>
<td>(4.1 – 8.6)</td>
</tr>
<tr>
<td>Primary school completed</td>
<td>71 (17.0)</td>
<td>(13.6 – 20.6)</td>
</tr>
<tr>
<td>Secondary school completed</td>
<td>105 (25.1)</td>
<td>(20.8 – 29.9)</td>
</tr>
<tr>
<td>High school completed</td>
<td>23 (5.5)</td>
<td>(3.6 – 7.9)</td>
</tr>
<tr>
<td>College/University completed</td>
<td>93 (22.2)</td>
<td>(18.7 – 26.1)</td>
</tr>
<tr>
<td>Postgraduate degree</td>
<td>12 (2.9)</td>
<td>(1.4 – 4.8)</td>
</tr>
<tr>
<td>Marital status</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Never married</td>
<td>116 (28.2)</td>
<td>(23.8 – 32.5)</td>
</tr>
<tr>
<td>Currently married</td>
<td>209 (50.7)</td>
<td>(45.9 – 55.6)</td>
</tr>
<tr>
<td>Separated</td>
<td>6 (1.5)</td>
<td>(0.5 – 2.7)</td>
</tr>
<tr>
<td>Divorced</td>
<td>12 (2.9)</td>
<td>(1.5 – 4.6)</td>
</tr>
<tr>
<td>Widowed</td>
<td>68 (16.5)</td>
<td>(13.1 – 20.1)</td>
</tr>
<tr>
<td>Cohabiting</td>
<td>1 (0.2)</td>
<td>(0.0 – 0.7)</td>
</tr>
</tbody>
</table>

The glycaemic status of the respondents is shown in Table 4.7.3. Of the sampled cohort of 418, 58.9% were hyperglycaemic and 41.1% had normal blood glucose level.

Table 4.7.3: Glycaemic status of the entire study population respondents

<table>
<thead>
<tr>
<th>Glycaemic status</th>
<th>Frequency (%)</th>
<th>(95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>172 (41.1)</td>
<td>(36.4 – 45.7)</td>
</tr>
<tr>
<td>Prediabetes</td>
<td>168 (40.2)</td>
<td>(35.6 – 45.2)</td>
</tr>
<tr>
<td>Diabetes</td>
<td>78 (18.7)</td>
<td>(14.8 – 22.2)</td>
</tr>
<tr>
<td>Total (N)</td>
<td>418 (100.0)</td>
<td>(100.0 – 100.0)</td>
</tr>
</tbody>
</table>
4.8 Application of Akaike Information Criterion in Public Health (Diabetes) Screening in Nigerian Rural Communities

Figure 4.5 indicates modelling of anthropometric as well as biochemical variables and ODI scores in the prediction of diabetes. Based on AIC, the best model remained FBG, and the least was (RBS + WC + HC) (Figure 4.5).

Key: FBS (FBG) = Fasting blood glucose, TC = Total cholesterol; HDL = High density lipoprotein; RBS = Random blood sugar, WC = Waist circumference, HC = Hip circumference; WHR = Waist-to-hip ratio

**Figure 4.5:** Modelling of anthropometric as well as biochemical variables and ODI scores of the overall study population
As discussed in Chapter 4, eight different discussions constitute this chapter; and each starts with a preamble, and ends with a conclusion. The contents of the preambles are detailed in the Literature Review of this study.

### 5.1 Prevalence of Hyperglycaemia and Risk Factors for Orodental Disease in Nigeria: Implications of Opportunistic Screening

#### 5.1.1 Preamble

In Nigeria, 70 – 80% of the 4 million people with DM remain undiagnosed, and therefore untreated (IDF, 2013). People show poor attitude towards diabetes screening, and approximately 20 – 30% of individuals with DM are identified after complications have manifested (Gillies et al., 2008). Early identification of DM, and thus intervention has been shown to slow and mitigate development of diabetic complications. Hence, clinical opportunistic screening can be useful for diagnosis of DM before symptoms are reported (Pereira Gray, Evans, Wright, & Langley, 2012). There is scope and room for opportunistic screening in orodental settings, since there is association between DM and orodental health (Preshaw et al., 2012). At present, there is little or no framework for opportunistic screening of DM in dental settings in Nigeria. In view of the foregoing, this study sort to assess the prevalence of hyperglycaemia in orodental disease patients with a view to suggesting opportunistic screening of hyperglycaemia in dental settings.
5.1.2 Inference of Result Findings

The results of this study show that the prevalence of hyperglycaemia in Ndokwa communities (56.8%) was less than obtained at the dental clinic (63.4%). These prevalences of hyperglycaemia comprise prediabetes and undiagnosed diabetes levels of blood glucose readings, respectively (Figure 4.1.1). A lower prevalence rate of 3% of UDM was reported by Ejike et al. (2015) in South-East, Nigeria. Shittu et al. (2017) observed a lower prevalence rate (10.6%) of hyperglycaemia in Oyo State, Nigeria compared to the observations in Ndokwa communities and dental clinic in the present study. A lower prevalence rate of less than 10% of hyperglycaemia was observed in Delta State, Nigeria by Nwose et al. (2015).

A prevalence rate of 12.7%, less than reported in this study was observed in Thailand (Dhippayom, Fuangchan, Tunpi, & Chaiyakunapruk, 2012). Nigeria, India and Thailand are developing countries most likely with similar socioeconomic variables, possibly excluding diet. Therefore, other factors such as genetics perhaps account for the observations. It is also possible that the higher prevalence of DM in this study is attributed to poor health seeking behaviour such as poor attitude towards diabetes of Ndokwa residents (Oguoma et al., 2014). The study by Dhippayom et al. (2012) was carried out in Bangkok, Thailand, where literacy levels are perhaps higher than in rural areas (Deepa et al., 2014), possibly explaining the lower prevalence noted. Lack of awareness of some rural inhabitants about DM probably accounts for the high prevalence observed in the current study. The finding of high prevalence of prediabetes and hyperglycaemia in dental
participants is significant, and can be used for opportunistic screening of DM. Studies show that early screening and treatment are cost-effective in management of diabetes (Waugh et al., 2007), and this can be achieved through opportunistic screening.

The highest occurrence of prediabetes (Figure 4.1.2) in the age group 18 – 29 years observed in the present study is in agreement with observations of increasing prevalence of T2DM in adolescents around the world (Reinehr, 2013), and justifies early screening to allow timely management that has been shown to delay progression of complications (Marshall & Flyvbjerg, 2006). A high prevalence of ODI (Table 4.1.3a and b) was observed in this study and studies in the USA show oral health to be important in overall health, and dental caries as well as tooth loss have been on the decline over the years, partly attributed to better treatment and attitudes in tooth preservation (Dye, Li, & Beltrán-Aguilar, 2012). Indeed, through education, communities can better orodental health, and this is cost-effective. It was observed in the current study that the subjects showed poor compliance in confirming their oral health status. This is in agreement with other studies that report oral disease burden in Nigerian rural communities to be high, with limited dental services. Studies note low health seeking behaviour and utilisation of dental services in rural communities in Nigeria (Ogbebor & Azodo, 2016), thus there is need for oral health promotion and screening in the population to minimize long term complications.

It is important to initiate community health approach in preventing the major ODIIs such as difficulty in biting or chewing food and feeling tensed
because of problems with teeth or gum, among others, which were observed in the study. This involves education on general health, especially oral hygiene practice. The relevance of the foregoing is in contributing data to reveal the occurrence of hyperglycaemia and ODIs in the study area. Tooth/mouth pain or discomfort was the most prevalent ODI in the current study, suggesting that it is the most occurring sign of orodental disease to be considered. The occurrences of the individual ODIs such as tooth/mouth pain are possibly associated with sociocultural determinants. Such determinants include poor living conditions, poor access to safe water or sanitary facilities and low education levels and lack of tradition, beliefs and culture that promote good oral health (Petersen, 2003). Another important determinant could be food and lack of essential vitamins from diets.

There was no difference in the FBG levels in males and females in Ndokwa communities and dental clinic, but females had higher mean blood triglyceride and HDL-C levels as well as WC values. In the dental participants, HC was also higher in females than in males (Table 4.1.1). In a hospital-based study in Ethiopia, more elevated mean levels of FBG, HDL-C and TC were observed in females than males (Ambachew, Shimelis, & Lemma, 2015), and this agrees with findings of this report. A study in Liaoning Province in China showed that the mean age, FBG and HDL-C concentrations in blood were higher in males than in females (Sun et al., 2014), contrasting findings of same indices in the present study, perhaps because it is a population study. However, blood levels of TC and WC values were greater in females than in males (Sun et al., 2014), and this is in agreement with observation for TC and WC in the present study. Hajian-
Tilaki and Heidari (2015) showed that HC mean value was higher in females than in males, thus corroborates the present study. That study observed that some female participants were menopausal, and this can alter lipid profile. The hormonal changes associated with menopause exert a significant effect on metabolism of plasma lipids and lipoproteins, as it decreases lipids levels (Bade, Shah, Nahar, & Vaidya, 2014).

In a hospital-based study in India, Mandal, Kumari, and Mukherjee (2015) showed that TC, triglyceride and HDL-C levels of females were higher than the males. Gender differences in the study might be due to different cut-off points of some indices such as WC and HDL-C (Regitz-Zagrosek, Lehmkuhl, & Mahmoodzadeh, 2007). The majority of the metabolic components measured BMI, FBG, HDL-C and triglyceride are gender dependent, and the contribution of these components to MetS is different in men and women (Beigh & Jain, 2012). This perhaps contributes to gender specific differences encountered in this study. It is possible that some of the females who had not reached menopause were on contraceptives. Contraceptives are reported to alter lipid profile in various populations with different patterns of dyslipidemia and cardiovascular risk (Asare et al., 2014). The reported higher levels of lipids (TC and triglycerides) among females could probably be due to high consumption of food and/or food products with potentials to elevate the mentioned lipids.

In this study, the mean age of those with prediabetes in Ndokwa communities and dental clinic were 43.2±19.6 and 36.9±14.1 years, respectively. It is known that prevalences of prediabetes increase with age
(Suastika, Semadi, Dwipayana, & Kuswardhani, 2012), since ageing decreases insulin sensitivity, and there is also alteration or insufficient compensation of beta cell function in the face of increasing insulin resistance (Chang & Halter, 2003). The study also noted 51.9±17.2 and 59.8±10.0 years as mean ages at diagnosis of T2DM in Ndokwa and dental clinic, correspondingly. The CDC in 2011, reported that the mean age at diagnosis of diabetes was 54 years in USA (CDC, 2015), which is comparable to the results of the present study. The slight difference is perhaps due to factors that include sampling more subjects in the age group of the highlighted ages. The 59.8 years noted in dental communities was probably because they were patients, and orodental disease is associated with DM (Andriankaja & Joshipura, 2014; Ueno et al., 2010). The mean age at diagnosis of T2DM in USA was 52.0 years, as reported in the HNANES III sample period (1988 – 1994) (Koopman, Mainous, Diaz, & Geesey, 2005).

This study observed the mean levels of blood TC, HDL-C, and triglyceride, WC, HC and WHR to be higher in diabetics than in prediabetics. This is probably due to diabetes escalating to complications, including weight gain (Jacob, Salinas, Adams-Huet, & Raskin, 2007). Dyslipidaemia is related to obesity, and obesity causes insulin resistance (Singh, Singh, Singh, Agrawal, & Gopal, 2011). Obesity is associated with high WC, HC and WHR possibly explaining why levels of TC, triglyceride, WC, HC and WHR were more elevated in diabetics than prediabetics. Most cross-sectional studies suggest that waist circumference or WHR are better indicators of diabetes risk than BMI (Bade et al., 2014) and these indices are
affordable, thus can be useful and affordable predictors of diabetes. The remarkable phenomenon about a decreased mean level of HDL-C observed in the prediabetics is its ability to exacerbate to frank DM and other complications such as dyslipidaemia and hypertension (Brunner, Shipley, Witte, Fuller, & Marmot, 2006; Marshall & Flyvbjerg, 2006). The former and later complications are markers of CVD, underscoring the need for screening program, preventive strategy and risk factor detection for prediabetes (Iraj, Salami, Feizi, & Amini, 2015).

In Table 4.1.1, the mean value of TC in both study settings are within the classification of the National Heart, Lung and Blood Institute (NHLBI) as ‘desirable’ (NIH, 2001a), implying that the participants had good TC levels in blood. Mean blood HDL-C levels for males and females in Ndokwa communities were within the definition of IDF as ‘risk factor’ (IDF, 2013). The mean blood triglyceride levels observed in the study populations are in agreement with cut-off points set by IDF (2013) and NIH (2001a).

The blood triglyceride and TC levels (Table 4.1.2) measured in prediabetics were less than in diabetics, but within desirable range. This is probably pathophysiological since in DM, lipid abnormalities are prevalent because major key enzymes and lipid metabolic pathways are affected due to deficiency of insulin production and secretion (Mooradian, 2009; Sarfraz, Sajid, & Ashraf, 2016; Taskinen, 2002). For instance, insulin affects the synthesis of liver apolipoprotein, and regulates activity of lipoprotein lipase and cholesterol ester transport protein, which is responsible for dyslipidemia in DM (Çalışması, 2008; Mooradian, 2009). This means that in diabetes,
blood lipid levels are affected, because of interrelationship between carbohydrates and lipid metabolism. Hence, aberrations in carbohydrate metabolism affect lipid metabolism and vice versa (Chatterjee & Shinde, 2005). The lipid changes associated with DM are also attributed to increased free fatty acid flux secondary to insulin resistance (Mooradian, 2009). This therefore means that, if interventions to control rising lipid levels are not embraced, elevated levels of triglyceride and TC will likely become abnormal with time.

5.1.3 Conclusion

In countries such as Nigeria, where prevalence of diabetes is rising, opportunistic screening of DM becomes an option since most people are reluctant to check their glycaemic status. Opportunistic screening of diabetes in dental settings is relevant, and translational research on the best cost-effective approach is recommended.

5.2 Association of Hyperglycaemia and Orodental Health in Nigerian Rural Communities

5.2.1 Preamble

It has been reported that DM is a major global trigger of disability (Akter et al., 2014). The incidence and prevalence of the disease are rising in developing and developed countries, including Nigeria (Beulens et al., 2010). Poor oral health has a profound effect on general health, and several oral diseases are related to chronic diseases such as diabetes (Petersen, 2003). Increased incidence, prevalence and acuity of periodontitis are found
among adults with T2DM (Wang, Jen, Chou, & Lei, 2014). Prediabetes has been found to be associated with periodontal health (Andrianakaja & Joshipura, 2014; Zadik, Bechor, Galor, & Levin, 2010). Hyperglycaemia leads to impairment of gingival fibroblast synthesis, resulting to loss of periodontal fibers and supporting alveolar bone (Kiran, Arpak, Ünsal, & Erdoğan, 2005). It is therefore necessary to assess the relationships of ODIs, BOP, CAL, GR and periodontitis with hyperglycaemia. There is lack of studies in Nigeria to substantiate the relationship between hyperglycaemia and periodontal health. Hence, the present study is aimed at evaluating the association of both diseases.

5.2.2 Inference of Result Findings

The mean age of the subjects in the entire study population, both sexes combined was 46.3 years; and ranged from 20 to 77 years. Zimmermann et al. (2015) had a similar observation (46.4 years) in a population in Germany, where glycaemic status and periodontal parameters were assessed. Studies report that the prevalence of PD and tissue destruction increases with age (Carranza & Newman, 1996); and prevalence of hyperglycaemia also increases with age (Suastika et al., 2011). DM and periodontitis affect many people, and increase in frequencies with ageing (Rajhans, Kohad, Chaudhari, & Mhaske, 2011) and there are changes in properties of human collagen, which occur simultaneously with ageing; alongside metabolic abnormalities of DM. (Oliver & Tervonen, 1994). Therefore, alterations in collagen metabolism in diabetics, possibly adds to the progression of PD (Rajhans et al., 2011). Findings from this study
suggests a possible two-way relationship between hyperglycaemia and periodontal health.

This study is perhaps the first report on the prevalence of ODI in association with hyperglycaemia in Nigeria. The low prevalence rate of 6.3% of hyperglycaemia and ODI co-morbidity is perhaps due to interventional diabetes program, which has been on-going in the study area (Nwose et al., 2013). High prevalence of ODI (43.6%) on the other hand, probably reflects poor health behaviour of residents (Oguoma et al., 2014). The proportion of co-morbidity possibly means that, if oral hygiene is not embraced, future occurrence of periodontitis in the identified hyperglycaemia and ODI subjects is eminent. Periodontitis is a risk factor for DM (Preshaw et al., 2012), thus the prevalence of hyperglycaemia in the study area may increase in the future. ODIs signal periodontitis, and the later may increase the risk for exacerbating glycaemic control (Taylor et al., 1996) and periodontitis may also facilitate the risk for diabetic complications (Saremi et al., 2005; Thorstensson, Kuylensitiema, & Hugoson, 1996) in the study population.

PD is reported to associate with hyperglycaemia, yet the relationship of ODI, clinical parameters of PD and glycaemic control remains unclear. The prevalence of PD observed in the study at the dental clinic was 19.5% (Table 4.2.1). This could possibly be due to the dietary intake of the patients, as nutrition has been reported to impact periodontal health (Najeeb, Zafar, Khurshid, Zohaib, & Almas, 2016). In DM patients in Brazil, Drumond-Santana, Costa, Zenobio, Soares, and Santana (2007) reported a 49.1% prevalence of periodontitis. Rajhans et al. (2011) in India, reported the prevalence rate of periodontitis in diabetics to be 59.5%. Another study
in India noted 84.5% prevalence in T2DM patients (Rao & Rao, 2016). The studies in Brazil and India were carried out in hospital settings, and recorded higher prevalence than observed in the present study. The difference can be linked to the oral hygiene among the study cohorts, especially in relation to DM awareness. Perhaps, it is also due to the fact that Indian and Brazilian studies were hospital-based. From the above, there are chances that hyperglycaemic subjects may develop PD in future, and vice versa; if there is no intervention. In this study, orodental pathologies (41%) encountered in FMA, ranged from generalised stains to chronic marginal gingivitis and patients with gingivitis were 23.1% (Table 4.2.3). Results of co-morbidities (Table 4.2.4) presented by the patients at the dental clinic is worrisome. Co-morbidity of DM and orodental diseases has been reported (Anyasodor et al., 2016), and patients with DM have been observed to have gingivitis, and 60.8% prevalence has been reported in diabetics in Brazil (Silva et al., 2015).

Hyperglycaemia can activate pathways that increase inflammation, oxidative stress and apoptosis (Brownlee, 2005a), hence systemic inflammation that is associated with PD may affect diabetic state (Preshaw et al., 2012). This study observed BOP to be present in 71.8% of the patients at the dental clinic, and 17.9% of those with BOP presented with its severe form. Studies have reported positive association between BOP and hyperglycaemia. Andriankaja and Joshipura (2014); Javed et al. (2012); Morton, Williams, and Watts (1995) and Bridges, Anderson, Saxe, Gregory, and Bridges (1996) reported positive association between BOP and hyperglycaemia. The prevalence of BOP noticed in the study perhaps
reflects poor oral hygiene practice, and requires attention to contain it and in this case, health education is advocated.

GR is a common manifestation in most populations, and is an early sign of PD (Manchala, Vandana, Mandalapu, Mannem, & Dwarakanath, 2012). In this study, 100% of the patients had GR possibly signaling future PD in these subjects. The high prevalence of GR highlights the importance of diagnosis, especially as it relates to patients with hyperglycaemia. The progression of PD initiates CAL, which occurs through destruction of the periodontal ligament and its adjacent alveolar bone leading to GR and pathologic periodontal probing depth (Kinane, 2001). CAL occurring in all patients (100%) in the present study is evidence of periodontitis. There is a positive correlation between glycaemia and CAL, and this is increased by hyperglycaemia (Botero et al., 2012). The association observed between hyperglycaemia and orodental disease parameters/ODI shows promise as a potential diagnostic tool. In addition to existing monitoring and screening protocols, early prevention or control of DM and/or PD can be achieved.

5.2.3 Conclusion

This study showed a positive relationship between hyperglycaemia and periodontal health. The established link calls for studies to control both diseases, particularly in high risk populations. It is worthwhile to consider referring patients treated for hyperglycaemia to a dental clinic for evaluation of periodontal health as part of management regimen of hyperglycaemia. Dentists should consider hyperglycaemia in reviewing a dental patient’s medical history or recommend appropriate tests to ascertain glycaemia.
Adequate health education, especially that relates co-morbidity of hyperglycaemia and PD, is paramount to control both diseases.

5.3 Brief Critical Review of Data: Cost-Effectiveness of Community Diabetes Screening

5.3.1 Preamble

In developing countries, the cost-effectiveness of screening for T2DM remains unknown (Toscano et al., 2015). Diabetes places additional burdens on individuals and families of affected individuals (Fasanmade & Dagogo-Jack, 2014), leading to enormous socioeconomic loss (Ogbera & Ekpebegh, 2014). Despite efforts to improve control, DM is not only assuming pandemic proportions globally, but poised to affect developing countries more than developed world (Ogbera & Ekpebegh, 2014). Interventions against DM need to be adopted by health systems, and widely used in high risk populations. One of such interventions is evaluation of cost-effectiveness of community diabetes screening, but data to rationalise and substantiate it are lacking in Nigeria. Hence, this study is set to provide such data in a local context.

5.3.2 Inference of Result Findings

The burden of diabetes cost in Sub-Saharan Africa (SSA), including Nigeria is expected to worsen owing to rapid urbanisation and ageing population (Mbanya, Assah, Saji, & Atanga, 2014). This is evidenced by the incidence of hyperglycaemia (prediabetes: 0.113% and diabetes: 0.046%) in this study (Table 4.3.1). The observation shows that regardless of diabetes intervention through education in Ndokwa communities, the disease is rising. This
therefore calls for community screening, thus determination of a cost-effective approach to screening for UDM.

Based on the cost (N 300 00) of screening diabetes in not-for-profit hospitals, it costs N 300 000 to screening 1 000 people to identify less than 2 individuals with UDM. Considering the socioeconomic cost of DM, consideration needs to be made if it is worth spending such an amount to diagnose less than 2 cases of UDM. Economic evaluation in the form of cost-effectiveness analysis informs on priority setting in healthcare (George, Harris, & Mitchell, 2001). A study on cost-effectiveness analysis of screening, which was not aimed to detect diabetes, but those at high risk to develop the disease suggested that such screening in long term followed by an adequate program to promote and support lifestyle changes is cost-effective and cost-saving (Zhuo et al., 2012). Although people show poor attitude towards voluntary screening, it is necessary to give diabetes screening a priority. This is because delayed diagnosis of hyperglycemia may lead to an epidemic (Sagui, 2007), and subsequently huge socioeconomic loss (Muggeo, 1998). This effect will be profound in SSA, including Nigeria, where risk of diabetes complications is great and costly (Hall, Thomsen, Henriksen, & Lohse, 2011; Ortegón, Lim, Chisholm, & Mendis, 2012). To prioritise mass diabetes screening in Nigeria, factors as poverty, knowledge, culture that may attribute symptoms to other myths, lack of tools; basic infrastructure and inadequate training of health workers need to be addressed since these are possibly responsible for failure to detect DM (Oguejiofor et al., 2011). The impediments also increase the risk of misdiagnosis and delayed diagnosis. Reliance on
traditional, rather than on allopathic medicine is also a major obstacle that is prevalent in SSA (Mbanya et al., 2012).

5.3.3 Conclusion

Implementation of opportunistic screening to identify those at risk for diabetes will lead to detection of subjects with prevalent, previously UDM. Since the costs of initial preventive diabetes treatment exceed those of screening, population strategies aimed at high risk individuals can be rewarding (Palmer & Tucker, 2012; Zhuo et al., 2012). Information on the cost of managing diabetes and its complications is critical for cost-effective interventions and prevention measures, and it is crucial to factor in the importance of early screening and diagnosis of the disease in policy making.

5.4 Metabolic Syndrome and Periodontal Disease: A Triangular Relationship

5.4.1 Preamble

There is growing evidence, suggesting a relationship between MetS components and PD (Abreu, Lopes, Pereira, Pereira, & Alves, 2012; Gurav, 2014). It is reported that individuals with MetS are nearly twice likely to have periodontitis (Nibali et al., 2013). Two hypotheses have been suggested to explain the relationship between MetS and periodontitis. The first is a cause-effect association, but it requires longitudinal and large-scale studies to validate the particular disease implicated as the cause. The second hypothesis proposes a commonality in risk factors between the two conditions (Li, He, et al., 2009). This relationship is compatible with the hypothesis that chronic inflammation is an important factor in
pathophysiology underlying MetS and PD (Priyalakshmi & Sankari, 2014). There is a gap in knowledge and dearth of data to rationalise the association of MetS with PD in Nigeria, and the present study contributes such data.

5.4.2 Inference of Result Findings

This study is the first to report interaction of MetS and PD in Nigeria, and showed a positive relationship between MetS and ODI (PD). The MetS components measured associated well with ODI in subpopulations of correlation analysis (Tables 4.4.1), but the association in individuals was poor. Since ODI, which is the initial stage of PD related positively with MetS, it is worthwhile to use studies involving PD to discuss findings of this study. The report of D’Aiuto et al. (2008) in NHANES corroborates the observation that MetS is positively associated with PD. A link between MetS and PD was established in a study in China (Li, He, et al., 2009), and this supports findings of this study. In Jordan, Khader et al. (2008) also found a positive relationship between MetS and PD, which is consistent with this current report.

Periodontitis may expose individuals to MetS through mechanisms activated by the translocation of oral bacteria and/or their products into blood circulation. Immune and inflammatory processes that initiate or aggravate MetS may subsequently be triggered by these bacteria (Han, Shin, Kim, Paek, & Kim, 2012; Scannapieco, 2004). The inflammatory markers in the individual components of MetS can up-regulate the periodontal inflammatory process, and the constant periodontal inflammation may exacerbate inflammatory components of MetS (Gurav, 2014).
In Table 4.4.1, positive correlation of ODI scores with FBG was stronger among subpopulations than in individuals. It was also observed that ODI scores with BMI correlated better in the subpopulations than in individuals. FBG has been found to be one of the two most important metabolic components associated with PD, the other component being abnormal lipid metabolism (Shimazaki et al., 2007). A study in Jordan by Andriankaja and Joshipura (2014), where a link was observed between prediabetic condition and periodontal health confirms the observation of this study. In a study among US population, Choi et al. (2011) showed that periodontitis was positively associated in a linear relation with IFG and diabetes, and this finding supports the report of the present study.

In this study, ODI related better with BMI than FBG in the subpopulation compared to individuals; and has shown that BMI may be a potential risk factor for PD and *vice versa*. Thus, evaluation of BMI could be employed in periodontal risk assessment. This could be attributed to such factors as poor oral hygiene, lack of exercise and consumption of energy-dense nutrient-poor foods by the participants. The study of Al-Zahrani, Bissada, and Borawski (2003), using NHANES III database established an association between BMI and PD. In a study in United Arab Emirates among T2DM patients, Awad, Rahman, and Haidar Hasan (2015) reported no association between periodontitis and BMI. Another study among Japanese adults suggested that independent of BMI, a high WHR is associated with a risk of periodontitis, particularly in higher BMI categories. Nevertheless, individuals with low WHRs, and having any level of BMI had insignificant risk of periodontitis (Saito, Shimazaki, Koga, Tsuzuki, & Ohshima, 2001).
While studies suggest a positive association between obesity and PD, the extent of the correlation is not yet defined. Hence, more prospective studies are needed to clarify the relationship (Gurav, 2014). There are emerging ideas stating the possibility that increased secretion of mediators of inflammation may modify the response of periodontal tissues to the oral environment. The excessive production of adipokines can yield this effect (Levine, 2013).

The correlation between lipid profile and ODI (4.4.2) showed a negative/very weak association. Other studies gave conflicting accounts of lipid profile and PD to the observation of this study. For instance, Valentaviciene, Paipaliene, Nedzelskiene, Zilinskas, and Anuseviciene (2006) reported absence of relationship between serum lipids and PD among patients at Kaunas University of Medicine, Lithuania. In the Fourth Korean NHANES, Lee, Yi, and Bae (2013) showed that dyslipidaemia, except pre-hypercholesterolaemia was associated with periodontitis.

It is known that exacerbation of hyperlipidaemic state is linked with periodontal inflammation by the up-regulation of serum and GCF pro-inflammatory cytokines (Fentoğlu et al., 2011). Dyslipidaemia has been suggested to conduit to a pro-inflammatory state, resulting in elevated levels of pro-inflammatory cytokines and oxidative stress (Gurav, 2014). This leads to the presence of systemic inflammation, and can lead to down regulation of host protective mechanisms (Bullon et al., 2009). The observed differences in the results of this study can be attributed to methodological issues. Again, some factors such as genetics, hormonal
changes associated with MetS, age and gender differences as well as other uncontrollable factors are possibly implicated.

5.4.3 Conclusion

Findings of this study suggest a relationship between MetS and periodontal health. FBG and BMI associated well with PD, among the components that constitute MetS. This means that in addition to FBG, BMI can be used to predict PD and vice versa. There are still conflicting opinions from other reports on the relationship of DM and PD. More longitudinal, well-designed, multi-centric studies based on large populations are recommended to substantiate the relationship.

5.5 Triangular Relationship Between Hyperglycaemia, Liver Function and Periodontitis

5.5.1 Preamble

The relationship of diabetes and PD with liver function is poorly understood, and there is need to elucidate the relationship. Although studies have documented the association of DM and periodontal health (Preshaw et al., 2012), and relationship between liver enzymes and PD (Wang, Koh, et al., 2016), the triangular nexus involving hyperglycaemia, liver enzymes and PD is yet to be clearly established. Understanding the interaction of DM/prediabetes and PD with liver function, and use of serum liver markers as diagnostic tools can be informative. The use of routine liver markers needs to be considered in the cost-effective opportunistic screening of DM. This is with a view to augmenting existing DM and PD diagnosis.
5.5.2 Inference of Result Findings

Participants with prediabetes and diabetes, who were also PD patients in Groups 2 and 3, had significant BOP. There was at least 2-fold increased attachment loss in participants with DM/prediabetes and PD comorbidities (DM-PD and prediabetes-PD), in comparison to prediabetic or apparently healthy subjects. Furthermore, correlation coefficient (+0.72) indicated strong positive correlations between blood glucose concentrations and GR depths as shown in Table 4.5.1. Studies have reported that prediabetes/diabetes is associated with periodontitis (Lalla et al., 2011; Preshaw, 2008; Preshaw et al., 2012) and observations in the current study are in line with findings in Columbia (Lalla et al., 2007) that demonstrated increased odds of gingival/PD in DM cases compared with controls. The findings also corroborate a similar report in Pakistan (Haseeb, Khawaja, Ataullah, Munir, & Fatima, 2012), which showed that attachment loss was greater in diabetic cases than in non-diabetics. Progressive GR increases the risk of tooth loss secondary to CAL (Merijohn, 2016) and it has been reported that tooth and periodontal attachment loss is increased by hyperglycaemia (Botero et al., 2012).

Finding of the current study also indicated a significant positive relationship between FBG and GR. This is in agreement with other studies that have established a link between periodontal health and systemic disease conditions such as DM. For instance, in a study in Ethiopia, GR was observed in diabetic patients (Bahru & Abdu, 1992). The periodontitis observed in this study would have been advanced, since it involved GR,
which generally appears in severe cases of periodontitis (Preshaw et al., 2012).

The present study found that DM/prediabetes correlated well with PD (Table 4.5.1). Subjects with diabetes and poor orodental health had significantly higher FBG level compared to the control (Group 4). Botero et al. (2012) in a study in Columbia showed that subjects with diabetes and periodontitis had loss of periodontal clinical attachment (poor orodental health) compared to those without diabetes. Botero and colleagues reported a positive correlation between glycaemia and CAL. The trend of increase in mean blood glucose concentrations in participants was: Group 4 (control) < Group 1 (only prediabetes) < Group 2 (prediabetes and PD) < Group 3 (DM and PD). Diabetes has been described as a major risk factor for periodontitis with possibility of up to three-fold increased risk of periodontitis in diabetic patients (Casanova, Hughes, & Preshaw, 2014), and several studies have also indicated a two-way relationship between diabetes and PD and/or periodontitis (Chee et al., 2013; Gurav, 2016; Kalra et al., 2016; Preshaw et al., 2012).

Despite paucity of information associating DM/prediabetes and PD in Nigeria, results from periodontal examinations demonstrate existence of a relationship between these diseases in rural communities of Nigeria. This infers that good oral hygiene practices, in addition to living healthy lifestyles that promote control of metabolic diseases, could positively influence glycaemic control. There is therefore need for more research that includes populations across different regions of Nigeria to extend knowledge of co-morbidity with underlying mechanisms in different
settings. It was observed that PD as well as liver function biomarkers correlated well with FBG, but there is dearth of data on the link between the trio. While ALT has been reported useful to identify people at high risk of T2DM (Wang, Koh, et al., 2016), periodontal treatment has been shown to improve liver function parameters such AST and alkaline phosphatase.

5.5.3 Conclusion

This study confirms, and helps to establish the link between the trio of hyperglycaemia, PD and liver function. There is evidence of relationship between hyperglycaemia and liver function, and nexus between PD and liver function has been reported. This is substantiated by the fact that the liver is vital organ, and involved in many physiological processes. It is recommended that physicians and dentists periodically monitor the liver conditions of patients to improve treatment outcomes. However, the findings of the study are subject to more extensive research, involving a larger population.

5.6 Prediabetes and Cardiovascular Complications Screening in Nigeria: A Family Case Presentation

5.6.1 Preamble

There is an inter-relationship between periodontitis, lipids and the increase in metabolic risk factors for CVDs (Ramirez-Tortosa et al., 2010). It is observed that periodontitis shares some common risk factors with MetS, including hyperglycaemia, obesity, dyslipidaemia and elevated blood pressure (Han et al., 2010a). Family history of dyslipidaemia and DM is
relevant (Ghamar-Chehreh, Khedmat, Amini, & Taheri, 2013), since DM and dyslipidaemia are related; and co-morbidity of the latter and PD is possible, but there is insufficient data to rationalise occurrence of family history of dyslipidaemia in Nigeria.

5.6.2 Inference of Result Findings

This study reports a case of familial dyslipidaemia and prediabetes, with emphasis on metabolic disease risk factors. Dyslipidaemia is a common occurrence in diabetic and hypertensive subjects, and this was observed in this report and other studies in Nigeria have reported the same (Idogun, Unuigbe, Ogunro, Akinola, & Famodu, 2007; Jisieike-Onuigbo, Unuigbe, & Oguejiofor, 2011; Ogbera, Fasanmade, Chinenyere, & Akinlade, 2009; Okafor, Fasanmade, & Oke, 2008). This study reports of 55% members of a family having up to two metabolic disorders or risk factors, including dyslipidaemia that predispose to CVD. The observations of the present study are at variance with reports that suggest that populations with increased intake of fish and marine mammals have high levels of HDL-C (Onyemelukwe & Stafford, 1981). Although marine animal consumption was not measured in this study, it is noteworthy that the 48-year-old-man hailed and resided in Delta State, Nigeria, where fish and marine animals are consumed almost daily. The finding also contrasts suggestions that blacks have low prevalence of dyslipidemia possibly due to genetic, nutritional, and environmental factors (Kesteloot et al., 1989).

Based on the information the subject gave about their lifestyle, genetic predisposition is possibly implicated in hyperglycaemic and dyslipidaemic
conditions observed. Lifestyle intervention has been shown to limit risk factors that are associated with development of CVD in patients with T2DM (Chen et al., 2015). It is also known that prevention of T2DM is feasible through lifestyle intervention (Alouki et al., 2016; Gilis-Januszewska et al., 2011). Given the proportion that showed indications of MetS in this family, this study suggests following up family history of prediabetes and dyslipidaemia.

5.6.3 Conclusion

Family history of dyslipidaemia needs to be considered in the epidemiology of metabolic disorders in Nigeria; especially as it relates to the association of DM and orodental diseases. Failure to recognise the genetic nature of dyslipidaemia may lead to a missed chance of up to 55% family members with preventable CVD risk factors. It is worthwhile to expect co-morbidity of dyslipidaemia and PD, especially where diabetes exists in the same individual.

5.7 Behavioural Medicine: Lifestyle Modification Advice to Control Metabolic Diseases in a Nigerian Rural Population

5.7.1 Preamble

Most of the risk factors associated with T2DM are preventable, and it has been suggested that through lifestyle intervention, considerable reduction in T2DM incidence may be achieved (Gilis-Januszewska et al., 2011). Socioeconomic and socio-cultural factors are directly and indirectly associated with diabetes control and health outcomes (Gonzalez-Zacarias et al., 2016), which takes lifestyle advice into account. Some studies report of
lifestyle interventions that delay disease progression and development of co-morbidities/complications in subjects with T2DM (Chen et al., 2015; Schellenberg, Dryden, Vandermeer, Ha, & Korownyk, 2013). However, information is lacking to substantiate this in rural Nigerian communities, which in part formed the basis of this study. This pilot study investigated the extent of lifestyle modification in Nigerian adults, and it addressed socioeconomic and socio-cultural aspects of the study.

5.7.2 Inference of Result Findings

This study reports that diabetes control through lifestyle advice is feasible in rural communities of Nigeria, and likely leads to enhancement of lifestyle in high-risk population. More females than males reported being advised to practice lifestyle modification to control metabolic diseases. A study has highlighted gender differences in relation to management and control of chronic diseases such as diabetes during adolescence (Siddiqui, Khan, & Carline, 2013). Adherence to lifestyle advice to control DM is necessary, as it improves management of the disease (Alouki et al., 2016), which is reflected in quality of life of patients (Rubin & Peyrot, 2004). Gender comparative assessments are necessary to identify needs of men and women, so that resources are channelled appropriately to improve diabetes care (Undén et al., 2008). More studies are required in rural Nigeria, especially in Ndokwa to assess the extent to which diabetics adhere to lifestyle advice as well as health outcomes in relation to gender. This study is mindful that the higher positive response to lifestyle advice among female patients could be attributed to social factors.
The most (33.9%) reported lifestyle advice observed by the respondents was daily consumption of at least 5 servings of vegetables/fruits. The WHO/United Nations Food and Agriculture Organisation (FAO) recommends consumption of more than 400 g or five portions of combined fruit and vegetables daily to reduce the risk of T2DM, and minimise the chances of dietary risk factors (WHO/FAO, 2003). It has been suggested that vegetables, especially green leafy vegetables have beneficial effect on T2DM, and several studies show that increase in daily consumption of green leafy vegetables significantly reduces T2DM risk (Carter, Gray, Troughton, Khunti, & Davies, 2010; Cooper et al., 2012; Wang, Fang, Gao, Zhang, & Xie, 2016; Xi et al., 2014). The control of DM is achievable through consumption of fruits and vegetables, since they contain anti-oxidants, which counter reactive oxygen species production and activity (Dal & Sigrist, 2016).

A good number (30.3%) of the respondents also reported that they observed physical activity. Exercise plays a role in controlling insulin, prediabetes and diabetes-related complications (Colberg et al., 2010). It is reported that some factors such as extent of physical activity affect exercise fuel use, especially intensity and duration (Galbo, Tobin, & van Loon, 2007; Houmard et al., 2004). It is therefore advisable to include exercise or physical activity for optimal health in T2DM subjects (Colberg et al., 2010; Colberg et al., 2016).

The present study also reports that 58.9% of respondents were hyperglycaemic (prediabetes: 40.2% and diabetes: 18.7%). Although this study did not measure extent of adherence to lifestyle advice, the reported
prevalence of hyperglycaemia suggests that adherence was not encouraging. A follow-up study is recommended to ascertain the extent to which the subjects practice lifestyle modification advice.

Most participants with DM were above 40 years, completed secondary education and married. Marital status has influence over diabetes care, and reflects in the glycaemic control of a diabetic. It has been shown that a spouse’s/partner’s involvement in diabetes education program improves outcomes when compared to patients without partner support (Beverly, Miller, & Wray, 2008; Trief, Wade, Britton, & Weinstock, 2002).

The relationship between socioeconomic status and diabetes has been reported (Tang, Chen, & Krewski, 2003), and related to a greater prevalence of T2DM diabetes complications (Funakoshi et al., 2017). Studies have also indicated that the prevalence DM increases with age (Azimi-Nezhad et al., 2008; Dray-Spira, Gary, & Brancati, 2008), as evidenced in the present study. Regarding association of marital status and DM, some findings suggest that being single, divorced, and widowed statuses are associated with the disease (Bréchon, Czernichow, Leroy, & Blum-Boisgard, 2005; Poljičanin et al., 2012).

5.7.3 Conclusion

Metabolic diseases, including DM are on the increase globally. Studies have shown that T2DM can be prevented in high-risk subjects with IGT by lifestyle intervention (Li et al., 2008; Tuomilehto et al., 2001). Lifestyle modification reduces risk of developing CVD, diabetes and its complications. There is large number of people who are hyperglycaemic,
and those that may be living lifestyles that promote metabolic diseases such as diabetes in Nigeria. Future studies need to trail such individuals to ascertain the extent to which they heed advice on lifestyle modification.

5.8 Application of Akaike Information Criterion in Public Health (Diabetes) Screening in Nigerian Rural Communities

5.8.1 Preamble

The burden of DM in LMICs is increasing, and it is important to identify patients with this condition early. However, what constitutes the best parameter to predict diabetes is contestable, as some reports indicate that anthropometric indices can predict diabetes (Nahar, Dubey, Joshi, Phadnis, & Sharma, 2012; Sargeant, Bennett, Forrester, Cooper, & Wilks, 2002; Stevens et al., 2001). This led to the evaluation of AIC with other anthropometric parameters to ascertain what indices predict diabetes better than others. Application of AIC in community-based screening in Nigeria is one way to improve diabetes control, especially in rural communities, hence the importance of this study.

5.8.2 Inference of Result Findings

The study indicated that FBG remains the best predictor of diabetes, as it showed the least AIC value of 4. Given a set of models, the preferred model is the one with the minimum AIC value (Akaike, 1974); and this is supported Abdul-Ghani, Williams, DeFronzo, and Stern (2007) who reported that insulin secretion/insulin resistance index was useful as a predictor of future development of T2DM. This means that the less insulin
secreted to regulate blood glucose level, the more likely it is for blood glucose to predict diabetes; and vice versa. Indeed, FBG and 2-h plasma glucose are strong predictors of T2DM (Buijsse, Simmons, Griffin, & Schulze, 2011; Li, Bergmann, Reimann, Bornstein, & Schwarz, 2009; Noble, Mathur, Dent, Meads, & Greenhalgh, 2011; Rathmann et al., 2010), confirming findings of this study.

Blood glucose screening is an important tool to detect diabetes in subjects at risk of developing diabetes or asymptomatic. It is debated whether FBG screening is sufficient or oral glucose tolerance test is required to identify asymptomatic diabetes (DECODE Study Group, 1998). In this study, FBG selectively combined with some parameters to produce models with low AIC (Figure 4.5). FBG requires invasive procedure to collect the blood, and it is expensive and time consuming in LMIC. Blood glucose levels exhibits random variation, and is therefore indicative of current glycaemic status. It is suggested that primary prevention entails identification of high-risk subjects in their normoglycaemic state to prevent transition of prediabetes to overt diabetes (Lindström & Tuomilehto, 2003). A concern therefore is that rural dwellers with diabetes are diagnosed later, and by the time diagnosis is made, some of the complications have advanced into irreversible stages (Gamm, Hutchinson, Dabney, & Dorsey, 2003). In view of the foregoing, it is pertinent to employ model(s) that augment FBG in diabetes screening, since it is still not clear if FBG can adequately detect asymptomatic DM.

Anthropometric indices such as age, WHR, WC, age and gender as well lipid profile that includes TC and HDL levels are employed in predicting diabetes (Hadaegh, Shafiee, & Azizi, 2009). A study in the USA showed
WC to be a better predictor than WHR for DM (Wang, Rimm, Stampfer, Willett, & Hu, 2005). On the other hand, it has been suggested that WHR is an excellent predictor for the development of T2DM (Esmailzadeh, Mirmiran, & Azizi, 2004; Kaye, Folsom, Sprafka, Prineas, & Wallace, 1991). The predictive abilities of WC, WHR and BMI were demonstrated in a meta-analysis, and reported to have similar association with incident diabetes (Vazquez, Duval, Jacobs, & Silventoinen, 2007). A prospective study in Iran also showed WC and WHR to be predictors of incident diabetes (Hadaegh et al., 2009). Patients with T2DM frequently exhibit an atherogenic lipid profile (high triglyceride and low HDL-C), which increases risk of CVD compared with normoglycaemia subjects (Windler, 2005). This evidence is sufficient to predict T2DM. Stern, Williams, and Haffner (2002) developed two models to predict diabetes incidence. The first was a clinical model including age, gender, ethnicity, FBG, systolic blood pressure, HDL-C, BMI and family history of diabetes. The second model included 2-hour glucose, diastolic blood pressure, total and low density lipoprotein cholesterol, and triglyceride. Though not all parameters indicated in the model were included in present study, the models of Stern and colleagues further validate the discourse.

As identified in this study, combination of the measured anthropometric and biochemical indices holds promise of detecting DM, especially in asymptomatic state. This is because most of the discussed parameters constitute risk factors for diabetes. In rural communities where infrastructure for blood screening for diabetes is lacking and/or where
invasive procedure is not required, WHR and WC can be used to estimate diabetes risk. The generated models in the study included most of the MetS parameters as defined by Alberti et al. (2009). This observation supports the report that people with signs of MetS have increased risk of diabetes (Hanson, Imperatore, Bennett, & Knowler, 2002; Laaksonen et al., 2002) and CVD (Galassi, Reynolds, & He, 2006; Lakka et al., 2002). The interest in this study is a cost-effective screening procedure that can be considered an alternative to FBG, which is expensive and invasive. Therefore anthropometric parameters are possibly better options to lipid profile in predicting diabetes.

5.8.3 Conclusion

Early screening of diabetes remains indispensible in the control of diabetes, and there is strong argument for screening of subjects at risk for diabetes (ADA, 2002). According to studies, 50% of individuals with diabetes remain undiagnosed and while these are unaware of their condition, they are at risk for complications of diabetes and risk of CVD. Anthropometric parameters are promising in predicting diabetes, whether in combination with FBG or independently, making this an option to consider in community diabetes screening especially in rural communities, where facilities for FBG screening are lacking.
CHAPTER 6: SUMMARY, LIMITATIONS AND RECOMMENDATIONS FROM THE STUDY

This chapter consists of three subsections: summary, limitations and recommendations for the study.

6.1 SUMMARY

- There is confirmation from the present study and other epidemiological studies that DM has a relationship with orodental health. Early screening of DM, which favourably impacts on PD, has potential to slow the epidemic of both diseases. Findings from the study support the observation that risk of periodontitis is increased in poorly controlled glycaemic state. This is because individuals with poorly controlled diabetes are at an increased risk of periodontitis and alveolar bone loss (Pihlstrom, Michalowicz, & Johnson, 2005; Soskolne & Klinger, 2001). Therefore, projections that DM prevalence is increasing imply that prevalence of PD will also increase.

- Furthermore, this can be ameliorated by good glycaemic control, manipulation of the risk factors (especially those common to both diseases) to favour disease control and good oral healthcare behaviours. There is a clear relationship between degree of hyperglycaemia and severity of PD, but the underlying mechanisms of links between prediabetes/DM and PD are poorly understood. There is emerging evidence to support the existence of a two-way relationship between diabetes and periodontitis, with diabetes
increasing the risk for periodontitis; and periodontal inflammation negatively affecting glycaemic control. Oral and periodontal health should be considered as integral components of diabetes. Application of the findings of this study can yield substantial benefits in the control of metabolic diseases, especially DM and also help in the control of PD.

- This study contributes to the growing evidence for the association of DM and oral health and offers solution to delayed screening for hyperglycaemia and dyslipidaemia. Findings of this study suggest that it is feasible to opportunistically screen these metabolic conditions at dentistries, but recommend studies using a larger population to validate. The association of DM and oral health is complex and not likely to be elucidated in one study.

- This study found a relationship between MetS components and PD (indicated by ODI) and also suggests a relationship between DM/prediabetes, PD and liver function. It considered the fact that the liver is a vital organ, as it carries out many physiological processes such as metabolism of glucose and lipids. Lifestyle modification can be employed to control metabolic diseases such as diabetes. However, this study only assessed the extent to which patients heed lifestyle advice. Anthropometric parameters show promise in predicting diabetes, whether in combination with FBG or independently. In settings where diabetes screening, using invasive
procedures is not feasible or in situations where screening is costly, diabetes risk prediction with anthropometric indices is an option.

- Observation relevant to diagnostic pathology is that point-of-care blood glucose testing is available e.g. in patent medicine stores, but cholesterol profile testing is not easily accessible. The implication is that holistic screening of MetS that includes cholesterol profile test is as yet unachievable.

6.1.2 Limitations

- The residents of Ndokwa communities who showed indication of PD were referred to EBGH dental clinic for confirmation, but unfortunately, only 2 people visited the dental clinic out of over 171 identified, possibly due to the long distance, engagement at work, market, school, etc. Some individuals also requested monetary incentive to participate in the study at EBGH. Although this was addressed in the information sheet for the research and during briefing, the participants were uncompromising; perhaps a reflection of economic hardship.

- Further, the hot climate concomitant with lack of stable electric power supply to power a cooling system affected some point-of-care testing equipment. This was to the extent that a considerable number of test results were invalid and resources wasted. Cardiochek analyser malfunctions at high temperatures, and test affected during the data collection was only lipid profile.
6.1.3 Recommendations

1. Routine screening for hyperglycaemia and dyslipidaemia and other MetS components, especially when there is indication of PD and/or liver disease. This will help in stemming the rising tide of the mentioned diseases.

2. Public health education be intensified, especially in rural areas; where literacy level of majority of the residents is very low. This can be achieved by organising campaigns in market places, health centres, schools, family meetings, churches etc.

3. Government policies to provide and encourage medical services, especially in rural communities. To initiate this, incentives should to be given to the populace to encourage hospital visits for check-up and treatment.

4. Employing anthropometric measurements to augment FBG test in the prediction of diabetes, especially in rural communities is recommended. This is because anthropometric measurements are affordable.
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Appendices

Appendix I: Participant Information Sheet

PARTICIPANT INFORMATION SHEET FOR SUBJECTS IN NDOKWA COMMUNITIES & EKU HOSPITAL

Cardiovascular risk assessment in prediabetes and undiagnosed diabetes study

Invitation:

You are invited to participate in the research on ‘Study of the Association of Diabetes Mellitus and Orodental health in Rural Communities of Nigeria’. The study is conducted by Anayochukwu Edward Anyasodor. He is Doctor of Philosophy (PhD) student of the School of Community Health, Charles Sturt University, Australia. The student is being supervised by Dr Ezekiel U. Nwose, Dr Ross S. Richards and Dr Phillip T. Bwititi. The investigation is in collaboration with Nigerian Novena University and Dr Luke Itietie of Eku hospital, all in Delta State

What is the purpose of this study? It is aimed at the feasibility of cost-effective opportunistic screening of diabetes mellitus (DM) and prediabetes in orodental clinic. In achieving the purpose of the research, some hypotheses and questions are considered. The hypothesis is prevalence of DM/prediabetes and metabolic syndrome (MetS) in Ndokwa communities correlates with the prevalence of periodontal disease. Adjunct to this hypothesis is that family history of poor orodental health in Ndokwa communities correlates with diabetes and CVD. The research questions are (1) what are the socioeconomic and socio-cultural burdens of DM/prediabetes and orodental disease in Ndokwa and Eku hospital? (2) What could be the cost-effective way to enhance early screening of DM/prediabetes in Ndokwa and Eku hospital? Thus, the objectives are to test the hypothesis and explore the research questions.

Why have I been invited to participate in this study? The study intends to recruit participants who are aged 18 years and above. Subjects who are pregnant at the period of the screening and known diabetics will be excluded from the study. Participants who are undergoing anticoagulation therapy, have systemic disease such as cancer and bleeding tendencies; among others will not be enrolled.

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What does this study involve? If you agree to participate, you will be asked to voluntarily sign a consent form. You will then be required to complete a questionnaire that will ask questions about your medical history and lifestyle including dietary, personal healthcare, physical activity and social habits. It will take you approximately 25 - 30 minutes to complete this questionnaire. Your weight, height, body mass index, waist circumference, hip circumference and blood pressure will be measured. These measurements will be taken as they are indicators of risk of diabetes mellitus and metabolic syndrome. A small sample of your blood will be taken, and it will be tested to determine your blood sugar and lipid profile. You will be asked to do dental/oral screening at Eku hospital. This is to know more about the relationship between diabetes and orodental health.

Do the participants have a choice about whether to involve a family member or not and who constitutes a family member? The participants would have a choice about whether to involve the family member(s) or not. Participation of the invited family member(s) would only occur following signing a consent form. Sibling(s), parent(s), uncle(s), cousin(s), nephew(s), niece(s) and aunt(s) constitute family members. These are the people to be invited to investigate family history of diabetes and orodental disease.

Are there risks and benefits to me in taking part in the study? The benefit of participating in the study is that the blood and physical examinations and dental/oral screening are free of charge. You will be informed, whether you have diabetes, prediabetes and/or orodental disease. You might feel a slight pain on your finger during blood collection.

Compensation: There will be no monetary compensation for participants in this study. Medical services (tests, subsequent consultations, counselling, follow-ups and referrals) offered shall be free of charge.

How your own results will be passed onto you: In the event that you have prediabetes or undiagnosed diabetes and/or orodental disease, you will be contacted. You would be asked to indicate if a next-of-kin is to be informed on your behalf, and/or elect to take the result to your General Practitioner with a reference letter from a Medical Advisor.

How the results will be used: The results will be securely stored in a computer database as electronic medical record for the primary health care (PHC), which would be accessed only by the coordinator, PHC office and your health counselor or the doctor you choose to show the report. Portions of the result would also be de-identified and analysed to develop PHC ‘fact sheets’ and publications. The results of the study will be disseminated through presentation in community, public lectures and scientific conferences as well as publication on health-related journals.
Confidentiality: There will be confidentiality of your identity. Your results will be de-identified and grouped in any publication. Due to confidentiality and privacy policy, your results will only be given to yourself, and any next-of-kin you nominate.

Who should I contact if I have concerns about the conduct of this study?

Note: Your participation in this screening is voluntary and you can withdraw at any time. NOTE: Charles Sturt University’s Human Research Ethics Committee has approved this project. If you have any complaints or reservations about the ethical conduct of this project, you may contact the Committee through the Executive Officer (see below). Alternative authorities to contact are also provided next page.

Charles Sturt University’s Human Research Ethics Committee

The Executive Officer

Human Research Ethics Committee

Tel: (02) 6338 4628

Email: ethics@csu.edu.au

Alternatively, you may contact

1. Office of the Chairman, Research Ethics Committee, Novena University Ogume through
   Dr Kester Digban
   Tel: +2348055276353
   Email: kadigban@yahoo.com

2. The Ndokwa West Local Council Health Department Supervisory Councillor for Health
   Tel: +2347067143027
   Email: mekuszy@yahoo.com

Contact details of the researcher:

Anayochukwu Edward Anyasodor

Tel: +61470373053

Email: aanyasodor@csu.edu.au

Thank you for considering this invitation.

This information sheet is for you to keep.
Appendix II: Consent Sheet

Research Consent Form

Project Title: Study of the Association of Diabetes Mellitus and Orodental Health in Rural Communities of Nigeria

Chief Investigator: Anayochukwu Edward Anyasodor

Supervisor (s): Dr Ezekiel U. Nwose, Dr Ross S. Richards and Dr Phillip T. Bwititi

- I have read the accompanying information sheet and understood the purposes, and procedures of this study; and what my role as a participant will be, including any discomfort associated with the research.
- I consent to participating in the above research project, and give my consent freely.
- I consent to the researchers to contact my health facility and access my medical records to extract information about my health history.
- I understand that the researchers will de-identify any collected information for publication.
- I understand that participation in this study is completely voluntary. Therefore, I can withdraw from the study at any time before all data are collected without explanation or consequence.
- I understand I may experience brief, mild discomfort when performing the finger prick to collect blood samples and during orodental screening.
- I have been provided the opportunity to ask questions, and received satisfactory answers.

Charles Sturt University’s Human Research Ethics Committee has approved this study.

I understand that if I have any complaints or concerns about this research I can contact:
Executive Officer
Human Research Ethics Committee
Office of Academic Governance
Charles Sturt University
Panorama Avenue
Bathurst NSW 2795

Phone: (02) 6338 4628
Fax: (02) 6338 4194

Name: ____________________________________________
Participant’s signature: ___________________________ Date: ______________
Investigator’s signature: __________________________ Date: ______________
Appendix III: WHO Questionnaire

Study of the Association of Diabetes Mellitus and Orodental Health in Rural Communities of Nigeria

Have you consented to complete the questionnaire, having read the consent form?

Yes □ No □ (If no, please do not complete the questionnaire)
<table>
<thead>
<tr>
<th>Location and Date</th>
<th>Response</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cluster/Center/Village ID</td>
<td></td>
<td>11</td>
</tr>
<tr>
<td>Cluster/Center/Village name</td>
<td></td>
<td>12</td>
</tr>
<tr>
<td>Interviewer ID</td>
<td></td>
<td>13</td>
</tr>
<tr>
<td>Date of completion of the instrument</td>
<td>dd mm year</td>
<td>14</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Consent, Interview Language and Name</th>
<th>Response</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consent has been read and obtained</td>
<td>Yes</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>No</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>IF NO, END</td>
<td>15</td>
</tr>
<tr>
<td>Interview Language (Insert Language)</td>
<td>English</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>[Add others]</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>[Add others]</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>[Add others]</td>
<td>4</td>
</tr>
<tr>
<td>Time of interview (24 hour clock)</td>
<td></td>
<td>17</td>
</tr>
<tr>
<td>Family Surname</td>
<td></td>
<td>18</td>
</tr>
<tr>
<td>First Name</td>
<td></td>
<td>19</td>
</tr>
<tr>
<td>Additional Information that may be helpful</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Contact phone number where possible</td>
<td></td>
<td>110</td>
</tr>
</tbody>
</table>
### CORE: Demographic Information

<table>
<thead>
<tr>
<th>Question</th>
<th>Response</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex (Record Male / Female as observed)</td>
<td>Male 1</td>
<td>C1</td>
</tr>
<tr>
<td>Male 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>What is your date of birth? (dd mm yyyy)</td>
<td>if Known, Go to C4</td>
<td>C2</td>
</tr>
<tr>
<td>How old are you?</td>
<td>Years</td>
<td>C3</td>
</tr>
<tr>
<td>In total, how many years have you spent at school and in full-time study (excluding pre-school)?</td>
<td>Years</td>
<td>C4</td>
</tr>
</tbody>
</table>

### EXPANDED: Demographic Information

<table>
<thead>
<tr>
<th>Question</th>
<th>Response</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>What is the highest level of education you have completed?</td>
<td>No formal schooling 1</td>
<td>C5</td>
</tr>
<tr>
<td>Less than primary school 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary school completed 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Secondary school completed 4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High school completed 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>College/University completed 6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post graduate degree 7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Refused 88</td>
<td></td>
<td></td>
</tr>
<tr>
<td>What is your (insert relevant ethnic group / racial group / cultural subgroup / category/background)?</td>
<td>[Locally defined] 1</td>
<td>C6</td>
</tr>
<tr>
<td>[Locally defined] 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>[Locally defined] 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Refused 88</td>
<td></td>
<td></td>
</tr>
<tr>
<td>What is your marital status?</td>
<td>Never married 1</td>
<td>C7</td>
</tr>
<tr>
<td>Currently married 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Separated 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Divorced 4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Widowed 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cohabiting 6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Refused 88</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Which of the following best describes your main work status over the past 12 months?</td>
<td>Government employee 1</td>
<td>C8</td>
</tr>
<tr>
<td>Non-government employee 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Self-employed 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-paid 4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Student 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Homemaker 6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Refused 7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unemployed (able to work) 8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unemployed (unable to work) 9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Refused 88</td>
<td></td>
<td></td>
</tr>
<tr>
<td>How many people older than 18 years, including yourself, live in your household?</td>
<td>Number of people</td>
<td>C9</td>
</tr>
</tbody>
</table>

(18H) STP Please approach to surveillance: Instrument v.3.0
**EXPANDED: Demographic Information, Continued**

<table>
<thead>
<tr>
<th>Question</th>
<th>Response</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Taking the past year, can you tell me what the average earnings of the household have been? (RECORD ONLY ONE, NOT ALL 3)</td>
<td>Per week</td>
<td>Go to Q5</td>
</tr>
<tr>
<td></td>
<td>OR per month</td>
<td>Go to Q6</td>
</tr>
<tr>
<td></td>
<td>OR per year</td>
<td>Go to Q6</td>
</tr>
<tr>
<td></td>
<td>Refused</td>
<td>88</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question</th>
<th>Response</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>If you don't know the amount, can you give an estimate of the annual household income? If I had some options to you? Is it (INSERT QUARTILE VALUES IN LOCAL CURRENCY)? (READ OPTIONS)</td>
<td>≤ Quartile (Q) 1</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>More than Q 1, ≤ Q 2</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>More than Q 2, ≤ Q 3</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>More than Q 3, ≤ Q 4</td>
<td>4</td>
</tr>
<tr>
<td></td>
<td>More than Q 4</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>Don't Know</td>
<td>77</td>
</tr>
<tr>
<td></td>
<td>Refused</td>
<td>88</td>
</tr>
</tbody>
</table>
### CORE: History of Raised Blood Pressure

<table>
<thead>
<tr>
<th>Question</th>
<th>Response</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Have you ever had your blood pressure measured by a doctor or other health worker?</td>
<td>Yes 1</td>
<td>H1</td>
</tr>
<tr>
<td></td>
<td>No 2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>If Yes, go to H2</td>
<td></td>
</tr>
<tr>
<td>Have you ever been told by a doctor or other health worker that you have raised blood pressure or hypertension?</td>
<td>Yes 1</td>
<td>H2a</td>
</tr>
<tr>
<td></td>
<td>No 2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>If No, go to H5</td>
<td></td>
</tr>
<tr>
<td>Have you been tested in the past 12 months?</td>
<td>Yes 1</td>
<td>H2b</td>
</tr>
<tr>
<td></td>
<td>No 2</td>
<td></td>
</tr>
<tr>
<td>In the past two weeks, have you taken any drug (medication) for raised blood pressure prescribed by a doctor or other health worker?</td>
<td>Yes 1</td>
<td>H3</td>
</tr>
<tr>
<td></td>
<td>No 2</td>
<td></td>
</tr>
<tr>
<td>Have you ever seen a traditional healer for raised blood pressure or hypertension?</td>
<td>Yes 1</td>
<td>H4</td>
</tr>
<tr>
<td></td>
<td>No 2</td>
<td></td>
</tr>
<tr>
<td>Are you currently taking any herbal or traditional remedy for your raised blood pressure?</td>
<td>Yes 1</td>
<td>H5</td>
</tr>
<tr>
<td></td>
<td>No 2</td>
<td></td>
</tr>
</tbody>
</table>

### CORE: History of Diabetes

<table>
<thead>
<tr>
<th>Question</th>
<th>Response</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Have you ever had your blood sugar measured by a doctor or other health worker?</td>
<td>Yes 1</td>
<td>H5</td>
</tr>
<tr>
<td></td>
<td>No 2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>If No, go to H2</td>
<td></td>
</tr>
<tr>
<td>Have you ever been told by a doctor or other health worker that you have raised blood sugar or diabetes?</td>
<td>Yes 1</td>
<td>H7a</td>
</tr>
<tr>
<td></td>
<td>No 2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>If No, go to H2</td>
<td></td>
</tr>
<tr>
<td>Have you been told in the past 12 months?</td>
<td>Yes 1</td>
<td>H7b</td>
</tr>
<tr>
<td></td>
<td>No 2</td>
<td></td>
</tr>
<tr>
<td>In the past two weeks, have you taken any drug (medication) for diabetes prescribed by a doctor or other health worker?</td>
<td>Yes 1</td>
<td>H8</td>
</tr>
<tr>
<td></td>
<td>No 2</td>
<td></td>
</tr>
<tr>
<td>Are you currently taking insulin for diabetes prescribed by a doctor or other health worker?</td>
<td>Yes 1</td>
<td>H9</td>
</tr>
<tr>
<td></td>
<td>No 2</td>
<td></td>
</tr>
<tr>
<td>Have you ever seen a traditional healer for diabetes or raised blood sugar?</td>
<td>Yes 1</td>
<td>H10</td>
</tr>
<tr>
<td></td>
<td>No 2</td>
<td></td>
</tr>
<tr>
<td>Are you currently taking any herbal or traditional remedy for your diabetes?</td>
<td>Yes 1</td>
<td>H11</td>
</tr>
<tr>
<td></td>
<td>No 2</td>
<td></td>
</tr>
</tbody>
</table>
### CORE: History of Raised Total Cholesterol

<table>
<thead>
<tr>
<th>Question</th>
<th>Response</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Have you ever had your cholesterol (fat levels in your blood) measured by a doctor or other health worker?</td>
<td>Yes 1</td>
<td>H12</td>
</tr>
<tr>
<td></td>
<td>No 2</td>
<td></td>
</tr>
<tr>
<td>Have you ever been told by a doctor or other health worker that you have raised cholesterol?</td>
<td>Yes 1</td>
<td>H13a</td>
</tr>
<tr>
<td></td>
<td>No 2</td>
<td></td>
</tr>
<tr>
<td>Have you been told in the past 12 months?</td>
<td>Yes 1</td>
<td>H13b</td>
</tr>
<tr>
<td></td>
<td>No 2</td>
<td></td>
</tr>
<tr>
<td>In the past two weeks, have you taken any oral medication (medication) for raised total cholesterol prescribed by a doctor or other health worker?</td>
<td>Yes 1</td>
<td>H14</td>
</tr>
<tr>
<td></td>
<td>No 2</td>
<td></td>
</tr>
<tr>
<td>Have you ever seen a traditional healer for raised cholesterol?</td>
<td>Yes 1</td>
<td>H15</td>
</tr>
<tr>
<td></td>
<td>No 2</td>
<td></td>
</tr>
<tr>
<td>Are you currently taking any herbal or traditional remedy for your raised cholesterol?</td>
<td>Yes 1</td>
<td>H16</td>
</tr>
<tr>
<td></td>
<td>No 2</td>
<td></td>
</tr>
</tbody>
</table>

### CORE: History of Cardiovascular Diseases

<table>
<thead>
<tr>
<th>Question</th>
<th>Response</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Have you ever had a heart attack or chest pain from heart disease (angina) or a stroke (cerebrovascular accident or ischemia)?</td>
<td>Yes 1</td>
<td>H17</td>
</tr>
<tr>
<td></td>
<td>No 2</td>
<td></td>
</tr>
<tr>
<td>Are you currently taking aspirin regularly to prevent or treat heart disease?</td>
<td>Yes 1</td>
<td>H18</td>
</tr>
<tr>
<td></td>
<td>No 2</td>
<td></td>
</tr>
<tr>
<td>Are you currently taking statins (lovastatin, simvastatin, atorvastatin or any other statin) regularly to prevent or treat heart disease?</td>
<td>Yes 1</td>
<td>H19</td>
</tr>
<tr>
<td></td>
<td>No 2</td>
<td></td>
</tr>
</tbody>
</table>

### CORE: Lifestyle Advice

<table>
<thead>
<tr>
<th>Advice</th>
<th>Response</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quit using tobacco or don’t start</td>
<td>Yes 1</td>
<td>H20a</td>
</tr>
<tr>
<td></td>
<td>No 2</td>
<td></td>
</tr>
<tr>
<td>Reduce salt in your diet</td>
<td>Yes 1</td>
<td>H20b</td>
</tr>
<tr>
<td></td>
<td>No 2</td>
<td></td>
</tr>
<tr>
<td>Eat at least five servings of fruit and/or vegetables each day</td>
<td>Yes 1</td>
<td>H20c</td>
</tr>
<tr>
<td></td>
<td>No 2</td>
<td></td>
</tr>
<tr>
<td>Reduce fat in your diet</td>
<td>Yes 1</td>
<td>H20d</td>
</tr>
<tr>
<td></td>
<td>No 2</td>
<td></td>
</tr>
<tr>
<td>Start or do more physical activity</td>
<td>Yes 1</td>
<td>H20e</td>
</tr>
<tr>
<td></td>
<td>No 2</td>
<td></td>
</tr>
<tr>
<td>Maintain a healthy body weight or lose weight</td>
<td>Yes 1</td>
<td>H20f</td>
</tr>
<tr>
<td></td>
<td>No 2</td>
<td></td>
</tr>
</tbody>
</table>
# Step 2  Physical Measurements

## CORE: Blood Pressure

<table>
<thead>
<tr>
<th>Question</th>
<th>Response</th>
<th>Code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interviewer ID</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Device ID for blood pressure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cuff size used</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Small</td>
<td>M1</td>
<td></td>
</tr>
<tr>
<td>Medium</td>
<td>M2</td>
<td></td>
</tr>
<tr>
<td>Large</td>
<td>M3</td>
<td></td>
</tr>
<tr>
<td>Reading 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Systolic (mmHg)</td>
<td>M4a</td>
<td></td>
</tr>
<tr>
<td>Diastolic (mmHg)</td>
<td>M4b</td>
<td></td>
</tr>
<tr>
<td>Reading 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Systolic (mmHg)</td>
<td>M5a</td>
<td></td>
</tr>
<tr>
<td>Diastolic (mmHg)</td>
<td>M5b</td>
<td></td>
</tr>
<tr>
<td>Reading 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Systolic (mmHg)</td>
<td>M6a</td>
<td></td>
</tr>
<tr>
<td>Diastolic (mmHg)</td>
<td>M6b</td>
<td></td>
</tr>
</tbody>
</table>

During the past two weeks, have you been treated for raised blood pressure with drugs (medication) prescribed by a doctor or other health worker?  
Yes 1  
No 2  

## CORE: Height and Weight

For women: Are you pregnant?  
Yes 1 (If Yes, go to M16)  
No 2  

| Interviewer ID                   |          |      |
| Device ID for height and weight  | Height   |      |
|                                  | Weight   |      |
| Height in Centimeters (cm)       | M10a     |
| Weight in Kilograms (kg)         | M10b     |

CORE: Waist

| Device ID for waist              |          |      |
| Waist circumference in Centimeters (cm) | M13     |

## EXPANDED: Hip Circumference and Heart Rate

<table>
<thead>
<tr>
<th>Hip circumference in Centimeters (cm)</th>
<th>M15</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reading 1</td>
<td>Beats per minute</td>
</tr>
<tr>
<td>Reading 2</td>
<td>Beats per minute</td>
</tr>
<tr>
<td>Reading 3</td>
<td>Beats per minute</td>
</tr>
</tbody>
</table>

WHO STEPwise approach to surveillance: instrument v3.0
Oral Health Questionnaire for Adults
<table>
<thead>
<tr>
<th>Identification number</th>
<th>Sex</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2. How old are you today?  
(\text{Years})

3. How many natural teeth do you have?  
- No natural teeth:  
- 1–9 teeth:  
- 10–19 teeth:  
- 20 teeth or more:

4. During the past 12 months, did your teeth or mouth cause any pain or discomfort?  
- Yes:  
- No:  
- Don’t know:  
- No answer:

5. Do you have any removable dentures?  
- Yes:  
- No:  
- A partial denture:  
- A full upper denture:  
- A full lower denture:

6. How would you describe the state of your teeth and gums? Is it “excellent”, “very good”, “good”, “average”, “poor”, or “very poor”?

<table>
<thead>
<tr>
<th>Teeth</th>
<th>Gums</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent</td>
<td>Excellent</td>
</tr>
<tr>
<td>Very good</td>
<td>Very good</td>
</tr>
<tr>
<td>Good</td>
<td>Good</td>
</tr>
<tr>
<td>Average</td>
<td>Average</td>
</tr>
<tr>
<td>Poor</td>
<td>Poor</td>
</tr>
<tr>
<td>Very poor</td>
<td>Very poor</td>
</tr>
<tr>
<td>Don’t know</td>
<td>Don’t know</td>
</tr>
</tbody>
</table>
7. **How often do you clean your teeth?**

<table>
<thead>
<tr>
<th>Frequency</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Never</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Once a month</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>2–3 times a month</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Once a week</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>2–6 times a week</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Once a day</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Twice or more a day</td>
<td>7</td>
<td></td>
</tr>
</tbody>
</table>

8. **Do you use any of the following to clean your teeth?**

(Read each item)

<table>
<thead>
<tr>
<th>Item</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toothbrush</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wooden toothpicks</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plastic toothpicks</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thread (dental floss)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Charcoal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chewstick/miswak</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Please specify</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

9. **Do you use toothpaste to clean your teeth?**

   a) Yes 1  No 2

   b) **Do you use a toothpaste that contains fluoride?**

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Don't know</td>
<td></td>
</tr>
</tbody>
</table>

154
10. How long is it since you last saw a dentist?

<table>
<thead>
<tr>
<th>Duration</th>
<th>Yes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 6 months</td>
<td>1</td>
</tr>
<tr>
<td>6–12 months</td>
<td>2</td>
</tr>
<tr>
<td>More than 1 year but less than 2 years</td>
<td>3</td>
</tr>
<tr>
<td>2 years or more but less than 5 years</td>
<td>4</td>
</tr>
<tr>
<td>5 years or more</td>
<td>5</td>
</tr>
<tr>
<td>Never received dental care</td>
<td>6</td>
</tr>
</tbody>
</table>

11. What was the reason of your last visit to the dentist?

<table>
<thead>
<tr>
<th>Reason</th>
<th>Yes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consultation/advise</td>
<td>1</td>
</tr>
<tr>
<td>Pain or trouble with teeth, gums or mouth</td>
<td>2</td>
</tr>
<tr>
<td>Treatment/ follow-up treatment</td>
<td>3</td>
</tr>
<tr>
<td>Routine check-up/treatment</td>
<td>4</td>
</tr>
<tr>
<td>Don't know/don't remember</td>
<td>5</td>
</tr>
</tbody>
</table>

12. Because of the state of your teeth or mouth, how often have you experienced any of the following problems during the past 12 months?

<table>
<thead>
<tr>
<th>Problem</th>
<th>Very often</th>
<th>Fairly often</th>
<th>Sometimes</th>
<th>No</th>
<th>Don't Know</th>
</tr>
</thead>
<tbody>
<tr>
<td>(a) Difficulty in biting foods</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(b) Difficulty chewing foods</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(c) Difficulty with speech/trouble pronouncing words</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(d) Dry mouth</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(e) Felt embarrassed due to appearance of teeth</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(f) Felt tense because of problems with teeth or mouth</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(g) Have avoided smiling because of teeth</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(h) Had sleep that is often interrupted</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(i) Have taken days off work</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(j) Difficulty doing usual activities</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(k) Felt less tolerant of spouse or people who are close to you</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(l) Have reduced participation in social activities</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
13. **How often do you eat or drink any of the following foods, even in small quantities?**
(Read each item)

<table>
<thead>
<tr>
<th></th>
<th>Several times a day</th>
<th>Every day</th>
<th>Several times a week</th>
<th>Once a week</th>
<th>Several times a month</th>
<th>Occasionally</th>
<th>Seldom</th>
<th>Never</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fresh fruit</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Biscuits, cakes,</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>cream cakes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sweet pies, buns</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jam or honey</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chewing gum containing sugar</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sweets/candy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lemonade, Coca Cola</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>or other soft drinks</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tea with sugar</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coffee with sugar</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(Insert country-specific items)

14. **How often do you use any of the following types of tobacco?**
(Read each item)

<table>
<thead>
<tr>
<th></th>
<th>Every day</th>
<th>Several times a week</th>
<th>Once a week</th>
<th>Several times a month</th>
<th>Seldom</th>
<th>Never</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cigarettes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cigars</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A pipe</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chewing tobacco</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Use snuff</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Please specify
15. During the past 30 days, on the days you drank alcohol, how many drinks did you usually drink per day?

<table>
<thead>
<tr>
<th>Less than 1 drink</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 drink</td>
<td>1</td>
</tr>
<tr>
<td>2 drinks</td>
<td>2</td>
</tr>
<tr>
<td>3 drinks</td>
<td>3</td>
</tr>
<tr>
<td>4 drinks</td>
<td>4</td>
</tr>
<tr>
<td>5 or more drinks</td>
<td>5</td>
</tr>
<tr>
<td>Did not drink alcohol during the past 30 days</td>
<td>9</td>
</tr>
</tbody>
</table>

16. What level of education have you completed?

| No formal schooling | 1 |
| Less than primary school | 2 |
| Primary school completed | 3 |
| Secondary school completed | 4 |
| High school completed | 5 |
| College/university completed | 6 |
| Postgraduate degree | 7 |

(Insert country-specific categories)

That completes our questionnaire

Thank you very much for your cooperation!

<table>
<thead>
<tr>
<th>Year</th>
<th>Month</th>
<th>Day</th>
<th>Interviewer</th>
<th>District</th>
<th>Country</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix IV: Supplementary Questionnaire

Survey & Demographic Information (Please check ✓ the box(es) appropriately)

1. Have you consented to complete the questionnaire, having read the consent form?
   Yes ☐ No ☐ (If no, please do not complete the questionnaire)

2. Last name (Surname): ................................................

3. First name: ..............................................................

4. Sex: Male ☐ Female ☐

5. Age: .................................

6. Contact address / phone number: .................................

7. Marital status: Single ☐ Married ☐ Divorced ☐ Widowed ☐
   Co-habiting ☐

8. What is your level of education? No formal schooling ☐ Less than primary school ☐ Primary school completed ☐ Secondary school completed ☐ High school completed ☐ College/University completed ☐ Postgraduate degree ☐

9. What is your occupation? Government employee ☐
   Non-government employee ☐ Self-employed ☐ Farmer ☐
   Student ☐ Retired ☐ Homemaker ☐
   Unemployed (able to work) ☐ Unemployed ☐

10. What is your geographic location? Close to city ☐ Abbi ☐ Kwale ☐

11. What is your ethnicity? Urhobo ☐ Isoko ☐ Ijaw ☐ Itsekiri ☐
    Igbo ☐ Yoruba ☐ Hausa ☐ Ukwani ☐ Specify others ........................
Laboratory Test Questionnaire (Multiple responses are allowed where appropriate)

12. Have you done any laboratory ‘blood’ test in this hospital before?
   Yes  ☐ No  ☐

13. If yes, do you remember the date? ........................................

14. Do you have diagnosis of diabetes mellitus? Yes  ☐ No  ☐

15. Do you have high cholesterol level? Yes  ☐ No  ☐

16. Do you have heart diseases? Yes  ☐ No  ☐

17. Do you have high blood pressure? Yes  ☐ No  ☐

18. Do you have metabolic syndrome? Yes  ☐ No  ☐

Laboratory Records (Multiple responses are allowed)

Routine Haematology:

19. Haematocrit (HCT/PCV) .................................................

20. Haemoglobin level ......................................................

21. Red blood cell count ...................................................

22. White blood cell count ................................................

Routine Biochemistry:

23. Total protein .............................................................

24. Albumin .................................................................

25. Total bilirubin ...........................................................

26. Serum creatinine .......................................................

27. Blood urea nitrogen ...................................................

28. Blood glucose level ...................................................

29. Total cholesterol ....................................................... 

30. Low density lipoprotein ..............................................

31. High density lipoprotein .............................................
Periodontal Examination

32. Full mouth assessment periodontal examination result:

33. Bleeding on probing:  No bleeding  □  Only one bleeding point appearing  □  Several isolated bleeding points or a small blood area appearing  □  Interdental triangle filled with blood soon after probing  □  Profuse bleeding when probing, blood spreads towards the marginal gingiva  □

34. Gingival recession result (mm):  

35. Clinical attachment loss result (mm):  

Interviewer identification number:  

Date of completion of the questionnaire:  

Time:  

Thank you for completing the questionnaire!
Appendix V: CSU Ethics Approval

27 November 2015

Mr Anayochukwu Anyasodor
School of Community Health
Charles Sturt University
346 Leeds Parade
Orange NSW 2800

Dear Mr Anyasodor,

Thank you for the additional information forwarded in response to a request from the Human Research Ethics Committee (HREC).

The CSU HREC reviews projects in accordance with the National Health and Medical Research Council’s National Statement on Ethical Conduct in Research Involving Humans.

I am pleased to advise that your project entitled “Study Of The Association Of Diabetes Mellitus And Orodental Health In Rural Communities Of Nigeria” meets the requirements of the National Statement, and ethical approval for this research is granted for a twelve-month period from 27/11/2015.

The protocol number issued with respect to this project is 2015/286. Please be sure to quote this number when responding to any request made by the Committee.

Please note the following conditions of approval:

- all Consent Forms and Information Sheets are to be printed on Charles Sturt University letterhead. Students should liaise with their Supervisor to arrange to have these documents printed;
- you must notify the Committee immediately in writing should your research differ in any way from that proposed. Forms are available at: http://www.csu.edu.au/_data/assets/word_doc/0007/963763/Report-on-Research-Project_20130503.doc (please copy and paste the address into your browser);
- you must notify the Committee immediately if any serious and or unexpected adverse events or outcomes occur associated with your research, that might affect the participants and therefore ethical acceptability of the project. An Adverse Incident form is available from the website: as above;
- amendments to the research design must be reviewed and approved by the Human Research Ethics Committee before commencement. Forms are available at the website above;
- if an extension of the approval period is required, a request must be submitted to the Human Research Ethics Committee. Forms are available at the website above;
- you are required to complete a Report On Research Project, which can be downloaded as above, by 21/10/2016 if your research has not been completed by that date;
- you are required to submit a final report, the form is available from the website above.

YOU ARE REMINDED THAT AN APPROVAL LETTER FROM THE CSU HREC CONSTITUTES ETHICAL APPROVAL ONLY.

If your research involves the use of radiation, biological materials, chemicals or animals a separate approval is required from the appropriate University Committee.

www.csu.edu.au

CRICOS Provider Numbers for Charles Sturt University are 00065F (NSW), 01947G (VC) and 02560B (ACT). ABN: 83 878 798 551
The Committee wishes you well in your research and please do not hesitate to contact the Executive Officer on telephone (02) 6338 4628 or email ethics@csu.edu.au if you have any enquiries.

Yours sincerely

Julie Hicks
Executive Officer
Human Research Ethics Committee
Direct Telephone: (02) 6338 4628
Email: ethics@csu.edu.au
Cc: Dr Ezekiel Nwose, Dr Ross Richards, Dr Phillip Bwiti

This HREC is constituted and operates in accordance with the National Health and Medical Research Council’s (NHMRC) National Statement on Ethical Conduct in Human Research (2007)
Appendix VI: Ndokwa West LGA Ethics Approval

NDOKWA WEST LOCAL GOVERNMENT COUNCIL
P. M. B. 006, KWALE,
DELTA STATE, NIGERIA

Dr. Ezekiel Uba Nwose (PhD, CSci, FIBMS, MAIMS),
Coordinator, Medical Laboratory Science Program,
School of Psychological and Clinic Sciences,
Charles Darwin University, Australia.

RE: ETHICAL APPROVAL/CONSENT TO CARRYOUT
FREE PREDIABETES AND CARDIOVASCULAR
COMPLICATIONS SCREENING IN NDOKWA WEST
LOCAL GOVERNMENT COMMUNITIES.

I am directed to refer to the above subject and to inform you that Ndokwa West
Local Government, Kwale has given ethical approval and consented to your
request.

I am further directed to add that the Local Government will be willing to
partner with you in similar subsequent exercise.

Wishing you a successful exercise.

O.T. AKPE (MNM)
For Chairman
Ndokwa West Local Government,
Kwale.

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Appendix VII: Ndokwa West LGA Indication of Support

NDOKWA WEST LOCAL GOVERNMENT COUNCIL
P. M. B. 006, KWALE,
DELTA STATE, NIGERIA

Our Ref: KW 1177/T/3
Your Ref: _____________________________ Date: 10th December, 2013

_______________________________

LETTER OF INTRODUCTION

I am directed to refer to the above subject and to introduce to you,
Dr Ezekiel Uba Nwose, coordinator of the free prediabetes and
cardiovascular complications screening in Ndokwa West Local
Government Communities.

I am further directed to add that you may give him and his team all
the necessary assistance required to make the exercise successful.

Thanks in anticipation for your usual cooperation please.

_______________________________
O. T. AKPE (MNIM)
For: Chairman
Ndokwa West Local Government,
Kwale.
Appendix VIII: Ethics Approval from Novena University

NOVENA UNIVERSITY, AMAI
DELTA STATE.

OFFICE OF THE CHAIRMAN, RESEARCH
ETHICS COMMITTEE
6th December 2013

Attention:
(i) Dr. Uba Nwose, & Associates
   Principal Investigator,
   School of Psychological & Clinical Sciences
   Charles Darwin University Australia

(ii) Dr. Kester Digban & Associates
    Co-investigator
    Department of Public & Community Health
    Novena University, Delta State –Nigeria.

LETTER OF ETHICAL CLEARANCE

RE: Cardiovascular Risk Assessment in Prediabetes and Undiagnosed
   Diabetes Mellitus study: International Collaboration Research.

Reference is hereby made to your letter of 7th October 2013 on the above subject
matter. After due consideration of your request as stated in your proposal, I am
pleased to inform you that the Research Ethics Committee of this institution has
approved that the study be conducted.

Furthermore, you are requested to send an update quarterly as the research
progresses.

This ethical clearance covers only the first phase of your research study which is
from January to December 2014.

Accept our congratulation as we work to attain health for all.

[Signature]
Prof A.A. Osakwe.

Director of Academic Planning &
Chairman, Research Ethics Committee.
STUDY OF THE ASSOCIATION OF DIABETES MELLITUS AND ORODENTAL HEALTH IN RURAL COMMUNITIES OF NIGERIA

You are invited to participate in a public health research screening exercise. The research is conducted by Anayochukwu Edward Anyasodor, under the supervision of Dr Ezekiel U. Nwose, Dr Ross S. Richards and Dr Phillip Bwititi. The research student and his supervisors are from Charles Sturt University, Australia.

The research is to take place in Ndokwa communities and Eku hospital. This study is expected to last for one year (September, 2015 – September, 2016). The purpose of the study is to identify individuals with undiagnosed diabetes, prediabetes and/or orodental disease. The health screening/tests are free of charge. If you decide to participate in this research, you will be requested to sign a consent form and complete a questionnaire.

The following clinical assessments will be carried out:

- Blood tests (Diabetes screening & lipid profile test)
- Periodontal examination
- Physical measurements

Note: Your participation in this screening is voluntary and you can withdraw at any time. Charles Sturt University’s Human Research Ethics Committee has approved this project.
Appendix X: Co-morbidity of Diabetes Mellitus and Orodental Diseases in Nigeria

REVIEW ARTICLE

Co-morbidity of Diabetes Mellitus and Orodental Diseases in Nigeria

Anayoitchi Edward Anyasodor, Ezekiel Uba Nwose, Ross Stuart Richards, Phillip Taderera Bwiihi, Kester Awhintomah Digban, Luke Itietha Mudanga, Efehirhe Agenbi and Okugumi Ojode

School of Community Health, Charles Sturt University, NSW, Australia; School of Biomedical Sciences, Charles Sturt University, NSW, Australia; Department of Public & Community Health, Novena University, Delta State, Nigeria; Dental Clinic, Ebu Baptist Hospital, Delta State, Nigeria; Department of Biochemistry, Delta State University, Abraka, Nigeria; Catholic Hospital Aha, Delta State, Nigeria

Abstract: Background: Although several epidemiological studies have reported an association between diabetes mellitus (DM) and oral health. However, the occurrence of the co-morbidity of both diseases has been more of suspicion than evidence-based. DM is a serious public health concern globally, and in Nigeria. Studies have separately documented the prevalence of DM and oral diseases, but data lack to adequately rationalize co-morbidity of both diseases.

Objective: The study aimed to report evidence of co-morbidity of DM and orodontal diseases in Nigeria.

Method: Data published between December, 1970 and June, 2015 were used in writing the review. These data were collated from electronic literature archives and databases.

Results: This review suggests evidence of the association of DM and oral diseases. It revealed that both diseases are densely distributed in South-East, South-West and South-West geopolitical zones of Nigeria, and sparsely spread across other regions of the country.

Conclusion: Co-morbidity of both diseases holds promise that will favour public health practice, especially in Nigeria. It is hoped that the association may lead to the establishment of a cost-effective DM screening protocol in Nigeria. Again, screening of DM in dentistry and vice versa may possible through the relationship of both diseases. It is recommended that the driving force of the co-morbidity be investigated.

Keywords: Co-morbidity, diabetes mellitus, Nigeria, opportunistic screening, orodental health, type 2 diabetes mellitus.

INTRODUCTION

Diabetes mellitus (DM) is a metabolic disorder characterised by chronic hyperglycaemia that results from defects in insulin secretion (synthesis), insulin action or both [1]. It is a major cause of death and disability worldwide [2, 3], and the incidence as well as prevalence of DM is increasing in both developed and developing nations [4]. A global estimate of 382 million people were diagnosed with diabetes in 2013, and the number is expected to increase to 592 million by 2035 [5]. It is estimated that a total of 4.6 million people die from diabetes yearly, and it accounts for 8.2% mortality rate from all causes throughout the world [6]. DM is associated with concomitant oral manifestations that impact dental care [7].

Good oral health and absence of orodental disease enable an individual to eat, speak and socialise without discomfort or embarrassment; and contribute to the general well being [8]. Oral diseases and orodental trauma constitute major health challenges globally [9-11]. Poor oral health has significant impact on general health, and several oral diseases are linked with chronic diseases such as diabetes [9]. Studies show that diabetics exhibit poorer oral health than nondiabetics in some oral conditions such as periodontitis, xerostomia and caries lesions [12], and the link between diabetes and periodontal disease (PD) has been reported [13, 14]. Evidence from other studies implicate DM to be a risk factor for the development of PD [16-18].

If an association between DM and orodontal diseases exists, then this would allow development of opportunistic screening of DM and orodontal diseases in DM and orodental health centres. Evaluation of models for DM screening in medical setting; using objective and self-reported features has been severally reported [19-21]; and diagnosis of high-risk individuals with simple methods and opportunistic screening has been recommended [22]. Data from the National Health and Nutrition Examination Survey (NHANES)
and the molar ones include malocclusion, transmitted anterior teeth, dental fluorosis and tumours [103]. Studies report high prevalence rates of PD [8, 104], and occurrence of the disease is related to oral hygiene and socioeconomic status.

The oral health status of adult diabetic patients was assessed by Ogundele et al. [28] who compared the diabetics with non-diabetics; halitosis, a sign of PD was observed in 64.6% of the diabetics and 72.2% in the controls, while periodontal abscess was recorded in 10.8% and 7.4% of the diabetics and controls, respectively. The study also reported that with adequate metabolic control, the oral health of a diabetic may not be significantly different from that of a non-diabetic, except xerostomia.

It appears that there is poor oral health in Nigeria, and this is common in rural communities where there are wide gaps in individuals’ understanding of oral health. In African regions where poverty prevails, oral health receives low priority; and limited resources are invested in the control of HIV/AIDS, malaria and tuberculosis rather than oral diseases [10].

Figure 4 above shows that DM and odontological diseases are distributed in Nigeria, but abundantly in the South-South as well as South-East geopolitical zones of the country. This is based on data of population-based studies accumulated over the years by the authors shown in Tables 1 and 2. The abundance of both diseases in the aforementioned zones is a pointer of a possible co-morbidity of the diseases there. Therefore, studies are required in these zones to validate it. The confinement of the diseases in the above mentioned geopolitical zones is disturbing. It could possibly be that many studies have not been carried out in other areas.

ASSOCIATION OF DIABETES AND ODONTOLOGICAL DISEASES

Studies suggest that DM is a systemic disease, and a threat to developing PD [16, 107, 108]. Studies on the association of DM, periodontal disease and subsequent tooth loss have been documented [109-112]. There is indication of biological and epidemiological relationship between PD and DM, particularly T2DM [14, 113]. The chance of developing periodontitis is increased by approximately three-folds in diabetic individuals compared with non-diabetics [114]. A number of cross-sectional and longitudinal studies among Pima Indian population proved the importance of DM as a major risk factor for periodontitis in the 1990s. The study reported the prevalence and incidence to be higher among those with T2DM compared to subjects without it [115, 116], and the increased risk of periodontitis was approximately three folds among those with T2DM [117].

Straus et al. [118] analyzed data on DM and PD of the NHANES 2003–2004. In the analysis, they reported that 93% of subjects who had moderate and severe PD as well as
undiagnosed DM, qualified criteria for DM risk of the American Diabetes Association (ADA). It has been emphasised that treatment of PD may enhance glycaemic control in individuals with DM [119, 120]. Most researches have been centered on T2DM as a risk factor for development of periodontitis, possibly due to its historical development in patients in their 40s and 50s. Nevertheless, T1DM had been implicated as a risk factor for periodontitis. Diabetic patients, including children and adults should be seen to be at risk of periodontitis [16]. A study showed that around 10% of children with T1DM (<18 years) presented with increased attachment loss and bone loss, notwithstanding comparable plaque scores [121].

Lalla et al. [122] in their study on diabetic children (6–8 years old) and non-diabetic controls, observed that the proportion of sites with indication of periodontitis was higher in diabetic children (20% and 8% of sites, respectively). It is crucial to recognise the relevance of the association of DM with periodontal disorders, and a variety of oral conditions including xerostomia and candidal infections are linked with DM [16].

PATHOGENIC AND PATHOLOGICAL RELATIONSHIP OF DIABETES AND ORODENTAL DISEASES

Knowledge of the pathogenic/pathological role in the relationship between DM and orodental diseases will be helpful in understanding the association. Recovery of several periodontal pathogens in diabetic and non-diabetic subjects has been reported. Thorstensson et al. [123] revealed that more diabetic cases compared to non-diabetics harboured Porphyromonas gingivalis and other pathogens identified in both groups included Aggregatibacter actinomyctecum, Campylobacter rectus, Capnocytophaga spp., Eikenella corrodens, Fusobacterium nucleatum and Prevotella intermedia. A study on young Japanese with T1DM validated some of the findings of Thorstensson et al. [123], with Takahashi et al. [124] reporting that a major part of the subjects with periodontitis harboured P. gingivalis and P. intermedia than those without periodontitis. These studies signify probable variations in microbial composition of subgingival biofilm between diabetic subjects and non-diabetics, but the clinical importance remains uncertain. Such disparities may occur from the effect of DM in changing the local metabolic environment within the periodontal pocket, and this favours the growth of certain microbial species [16]. When blood glucose level is poorly controlled, the resultant high levels in oral fluids may help microorganisms grow, and set the stage for PD [125]. DM has been associated with orodental disorder, and the present study is to validate the claim in a local context. This study will ascertain the extent as well as the feasibility of opportunistic screening.

It has been postulated that the mechanism for diabetic effect on PD is that diabetes-enhanced inflammation and apoptosis impact on the periodontal tissues [126]. Inflammation is the common feature of the pathogenesis of DM and orodental disorders such as periodontitis. Both T1DM and T2DM are associated with elevated levels of inflammation [127], and inflammatory response is marked by dysregulated release of host-derived mediators of inflammation and tissue...
breakdown [16]. The most widely studied mediators are interleukins (ILs), prostaglandins, tumour necrosis factor-α (TNF-α), receptor activator of nuclear factor-κB ligand (RANKL), matrix metalloproteinases (MMPs), T-cell regulatory cytokines and chemokines [128]. The pattern and rate of disease progression is dependent on the severity of inflammatory response in the periodontal tissues [129].

It is reported that inflammation plays an important role in the pathogenic mechanisms linking DM and periodontitis, and both T1DM and T2DM are associated with high levels of systemic markers of inflammation [127]. The increased inflammatory state in DM is implicated in microvascular and macrovascular complications, and it is apparent that hyperglycaemia can lead to the activation of pathways that elevate inflammation, oxidative stress and apoptosis [130]. Inflammation in the periodontal tissue is increased by diabetes, and gingival crevicular fluid levels of PGE2 and IL-1β are elevated in patients with T1DM who have either gingivitis or periodontitis compared to non-diabetics with the same level of PD [131]. Diabetic patients with severe periodontitis exhibit decreased polymorphonuclear leukocyte (PMN) chemotaxis compared with those with mild periodontitis [132]. In addition, diabetes sufferers with severe periodontitis show defective PMN apoptosis [133], and this may result in increased accumulation of PMNs in the periodontal tissue. Thus, giving rise to increased tissue destruction facilitated by frequent release of MMPs and reactive oxygen species (ROS) [16].

Furthermore, advanced glycation end-products (AGEs) when accumulated in the periodontal tissues, possibly involve in up-regulating periodontal inflammation in DM. The production of inflammatory mediators such as IL-1β, TNF-α and IL-6 takes place when AGE binds to its receptor (RAGE) [134]. The formation of AGEs leads to the production of ROS, which facilitates oxidant stress, and the vascular injuries implicated in many diabetes complications are contributed by endothelial cell changes that occur [135]. Increased susceptibility of periodontitis associated with DM may be influenced by apoptosis. The occurrence of apoptosis in matrix-producing cells may limit the chances for repair in inflamed tissues. Inducing tissue injury by acellularisation of P. gingivalis leads to increased fibroblast apoptosis [136], indicating another mechanism by which the ability for repair is inflamed in periodontal tissues [16].

Substantial evidence of an advanced state of PD among smokers has been documented [137, 138]. Singh et al. [139] have suggested that an essential constituent of cigarette smoke, aryl hydrocarbons possess the ability to inhibit bone formation, especially where PD-causing bacterial co-factors exist. This could explain how periodontal bone loss might be associated with cigarette smoking. Smoking of tobacco exerts enormous destructive effect on periodontal tissues, and facilitates the rate of developing PD [140]. There is indication that these aryl hydrocarbons may catalyse vascular disease progression, as measured by vascular calcification [141]. There is a link between smoking and DM and its complications, including neuropathy, nephropathy, retinopathy, cardiovascular dysfunction and hypertension; and abstinence from smoking is a significant risk factor in the management of DM [142].

The severity of PD in DM may signal a change in the pathogenic potential of bacteria, facilitating breakdown of periodontal tissues [143, 144]. This leads to recurrent and severe periodontal tissue breakdown [144]. The metabolic state in DM is affected by PD, and Gram negative anaerobic bacteria involved in periodontal infection probably affect poor glycemic control as well as increase the chances of diabetes complications [111, 144, 145].

COULD CO-MORBIDITY OF BOTH DISEASES FAVOUR OPPORTUNISTIC SCREENING OF DIABETES?

The association of DM and periodontal diseases holds a promise of insight into developing a screening protocol of DM in Nigeria, using the dental setting. Two studies that are related to the subject matter have been identified: Ogundode et al. [28] and Ojekunle et al. [101]. Their studies were on oral health status of diabetic patients and prevalence of undiagnosed diabetes in dental clinic, respectively. Both studies were institutional (dental setting), with different objectives from the present study. The proposed study seeks to establish a cost-effective opportunistic screening protocol of DM in dental settings. Opportunistic screening of DM is one of the prescribed and endorsed screening protocols by WHO [147]. Placing emphasis on oral health care involving DM and oral health would bring to fore a novel and timely approach to detect diabetes in Nigeria. If early identification of DM, possibly through opportunistic screening in dentistry is overlooked, future diabetes burden may be imminent.

CONCLUSION

Diabetes and oral diseases prevalence rates in Nigeria are still high as reviewed, but data are lacking to rationalise co-morbidity of both diseases. The occurrence of both diseases involves pathogenic and pathological mechanisms. Inflammation has been implicated in the interaction of both diseases. T1DM, which is the focus of this review, is linked to elevated levels of systemic biomarkers of inflammation that trigger immunological responses. Many people are still undiagnosed with DM, and there is need for its early detection and intervention to avert DM complications. The interaction of both diseases will favour public health by creating avenues to establish opportunistic screening for DM in dental clinics.

CONFLICT OF INTEREST

The authors confirm that this article content has no conflict of interest.

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Appendix XI: Prediabetes and Cardiovascular Complications Screening in Nigeria: A Family Case Presentation

Case Report

Prediabetes and cardiovascular complications screening in Nigeria: A family case presentation

Anayochukwu Edward Anyasodor, Ezekiel Uba Nwosu, Ross Stuart Richards, Phillip Taderera Bwiti, Luke Itietie Madiga, Efehire Agani

1. Introduction

Dyslipidemia is the commonest complication of prediabetes and diabetes mellitus, and it predisposes to premature atherosclerosis, causing cardiovascular and cerebro-vascular complications [9]. Prediabetes precedes diabetes mellitus, and it is associated with cardiovascular complications [11], and dyslipidaemia is a major risk factor for the development of cardiovascular disease (CVD) [12,14]. Individuals with prediabetes have multiple disturbances in lipoprotein metabolism resulting from various combinations of insulin deficiency, insulin resistance, and hyperglycaemia [3]. Cardiovascular disease remains the leading cause of mortality in Nigeria [18], but screening for prediabetes and CVDs is yet to receive sufficient attention, perhaps due to lack of accessibility, affordability, awareness or poor attitude towards screening. There is an inter-relationship between periodontitis, plasma fatty acids profile and the increase in metabolic risk factors CVDs [17]. It is observed that periodontitis shares some common risk factors with metabolic syndrome, including hyperglycaemia, obesity, dyslipidaemia and elevated blood pressure [6]. Information on the genetic predisposition of dyslipidaemia and prediabetes will lead to increased understanding of these metabolic disorders. Elsewhere, a meta-analysis of 46 lipid genome-wide association studies comprising >100,000 individuals of European ancestry established more comprehensive genetic profiles for various blood lipids, including LDL cholesterol, HDL cholesterol, and triglycerides [16]. Family history of dyslipidaemia and diabetes mellitus has been mentioned to be of immense relevance to clinicians [4]. People show poor attitude towards screening of both diseases, and there is evidence of co-morbidity of DM and oesophageal diseases in Nigeria [11]. Since DM and dyslipidaemia are related, co-morbidity of the latter and periodontal disease might be imminent, but data lacks to rationalise occurrence of family history of dyslipidaemia in Nigeria.

2. Case report

During the Prediabetes and Cardiovascular Complications Study (PACCS) in Nigeria, a 48-year-old man was screened, and diagnosed
with dyslipidemia. Based on the information the subject gave, he had zero smoking history, non-alcoholic, engaged in regular exercise and ate balanced diet. The anthropometric and biochemical measurements of the subject were taken. Blood pressure value of 140/90 mmHg, body mass index (28.4 kg/m²), waist and hip circumferences of 110 cm and 116 cm, respectively were realised. Waist/hip ratio of 0.948 was calculated.

Fasting blood sample was collected by finger-prick, and the biochemical measurements were carried out as per manufacturer’s instructions, using the Cardiogeh® analyser (Polymer Technology Systems, Inc. (PTS), Indianapolis, USA). The fasting blood glucose (102 mg/dL), 5.67 mmol/L, total cholesterol (296 mg/dL), 7.66 mmol/L, triglyceride (350 mg/dL), 3.95 mmol/L, and high density lipoprotein (HDL) (28 mg/dL), 0.72 mmol/L were realised. The nature of the case screening results informed the invitation and screening of his family members (Table 1).

2.1 Technical notes

Observation relevant to diagnostic pathology is that point-of-care blood sugar testing is widely available even in patent medicine stores, but cholesterol profile testing is yet to be easily accessible. The implication is that holistic screening of metabolic syndrome that includes cholesterol profile test is as unachievable by the healthcare practitioners. Further, the hot climate weather concomitant with lack of stable electric power supply affected some point-of-care testing equipments to the extent that a considerable number of test results were invalid and resources were wasted in this pilot study. During the screening exercise, this problem was sorted by provision of private electric supply at the hospital site. Compliance to fasting instruction was also a great concern and occupational as well as religious practices of this family made the screening, which was limited to early morning to be spread over 3 days.

3. Discussion

This study reports a case of familial dyslipidemia with prediabetes, especially in terms of metabolic disease risk factors. Dyslipidemia is a common occurrence in both diabetic and hypertensive subjects, and it was observed in this report; and other studies in Nigeria have mentioned same [7,10,13,19]. We report observation of 55% members of a family having up to two metabolic disorders or risk factors, including dyslipidemia that may predispose them to CVD. The present study contradicts the claim, and the result negates earlier report that populations with increased intake of fish and marine mammals have high levels of HDL-C [15]. It is noteworthy that the 48-year-old-man hailed and resided in Delta State, Nigeria: where fish and marine animals are customary consumed almost daily. The finding also contrasts suggestions that blacks have low prevalence of dyslipidemia possibly due to genetic, nutritional, and environmental factors [8].

Based on the information the subject gave about his lifestyle, genetic predisposition could be implicated in the hyperglycaemic and dyslipidemic conditions observed. Lifestyle intervention has been shown to limit risk factors that are associated with development of CVD in patients with type 2 diabetes (T2DM) [2]. It is also known that prevention of T2DM is feasible through lifestyle intervention [5]. Given the proportion of this family that showed indications of metabolic syndrome, we suggest following up family history of any indicative client with prediabetes and dyslipidemia.

4. Conclusion

It is recommended that family history of dyslipidemia be considered in the epidemiology of metabolic disease in Nigeria. Failure to recognise the genetic nature of dyslipidemia may lead to a missed chance for up to 55% family members with preventable CVD risk factors. It is worthwhile to expect co-morbidity of dyslipidemia and periodical disease, especially where diabetes exists in the same individual.

Conflict of interest

The authors have none to declare.

Authors’ contribution

A.A.E, EUN, RSR and PTB conceived the study. A.A.E was the main investigator, and drafted the manuscript. EUN, RSR, PTB and LIM and EA revised the manuscript. All authors read and approved the final manuscript.

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References


Appendix XII: Behavioural Medicine: Lifestyle Modification Advice to Control Metabolic Diseases in Nigerian Rural Population

Conclusions: Some of the clinical potentials of exercise and positive cognitive bias modification in groups of healthy individuals were found. The mixed pattern of findings however renders them inaccessible, leaving interpretations of the potential therapeutic benefits of positive CMB training open for future research.

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BEHAVIOURAL MEDICINE: LIFESTYLE MODIFICATION ADVICE TO CONTROL METABOLIC DISEASES IN A NIGERIAN RURAL POPULATION
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Introduction: Lifestyle modification reduces the risk of developing e.g. cardiovascular disease, diabetes and its complications. Lifestyle change is perhaps not only utilized in Nigeria, yet constitutes a driving force in combating the high prevalence of metabolic diseases. Hence, this study investigated the extent of lifestyle modification advice in Nigerian adults.

Methods: A cross-sectional study was undertaken in Ndokwa West, Delta State, Nigeria. Four hundred and eighty (480) apparently healthy adults aged 18 years and above were sampled. The WBO Stepwise questionnaire on risk assessment was used to elicit information on lifestyle advice from the subjects. Fasting blood glucose was also measured in these individuals, using CardioCheck® analyser.

Results: Few (18.4%) respondents confirmed they were advised to quit tobacco smoking, and 29.3% acknowledged being advised to reduce salt in their diet. However, 53.9% of the subjects reported they were instructed to eat at least five servings of fruits/vegetables each day; and 25%, admitted being encouraged to reduce fat in their diet. Only 30.3% said they were prompted to start or engage in more physical activity, and 27.9% agreed they were admonished to maintain a healthy body weight or lose weight. Of the sampled cohort, 58.9% were hyperglycemic and 41.1%, normal blood glucose level. Conditions: There is a large number of people who are hyperglycemic and those that may be living lifestyles that promote metabolic diseases such as diabetes in Nigeria. Future studies need to track such cohorts to ascertain the extent to which they heed advice on lifestyle modification.

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PSYCHOMOTORIC OUTCOMES IN PARENTS AND THEIR INFANTS AFTER FETAL OR POSTNATAL DIAGNOSIS OF COMPLEX CONGENITAL HEART DISEASE: A pilot study
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Background: Congenital heart disease (CHD) affects 1 in 130 newborns and contributes significantly to the reduced overall survival. While 50% of infants with complex CHD are diagnosed antenatally, these infants are often separated from their mother at birth and experience invasive medical procedures. This can have profound developmental consequences, with early life experiences shaping brain development, the immune system, and responses to stress. This prospective cohort study examined the prevalence and predictors of psychological morbidity in parents following fetal or postnatal CHD diagnosis, and the association between parental anxiety during pregnancy and infant socioemotional, behavioral and neurodevelopmental outcomes.

Methods: Parents of infants with a fetal or postnatal diagnosis of complex CHD (n=169) or healthy fetal morphology scan at 18-20 weeks gestation (n=74) complete clinical interviews and validated surveys (3-months post-diagnosis, 6, 12, 18 months postpartum). Salivary cortisol is collected on days 1, 2, and 3 days postnatal discharge (infants). Mother-infant interaction at 6-months and infant outcomes at 12-months (Bayley Scales of Infant Development, Strange Situation Procedure) are also assessed.

Results: Three months post-diagnosis, 46% and 42% of mothers in the fetal and postnatal groups respectively, report anxiety warranting clinical intervention, compared to 17% of mothers of healthy infants. Similarly, 50% and 46% of infants in the fetal and postnatal groups report anxiety warranting intervention, compared to 13% of infants of healthy infants. Post-diagnosis, 14% of fathers report self-harm ideation. Discussion: Links between parental anxiety and infant outcomes are being investigated. Results will inform models of clinical care for infants with CHD and their parents.

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ASSESSMENT OF HORMONAL PARAMETERS IN LONG-TERM KARATE PRACTITIONERS
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Introduction: Karate is a Japanese martial art which is widely practised in the Western world as a form of self-defense, as well as a discipline to achieve physical and mental balance. However, little is known with respect to its specific psychological effects, particularly in relation to the