EVALUATION OF THE POTENTIALS OF FINGERPRINT AND DIGIT RATIO IN SCREENING OF PATIENTS WITH BRONCHIAL ASTHMA

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MARCH, 2019

DECLARATION

I hereby declare that this work is the product of my research efforts undertaken under the supervision Dr M Abubakar and has not been presented anywhere for the award of a degree or certificate. All sources have been duly acknowledged.

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CERTIFICATION

This is to certify that the research work for this dissertation and the subsequent write up of 'Amina Danladi Muhammad, SPS/16/MAN/00002', where carried out under my supervision.

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DEDICATION

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ABSTRACT

Asthma is increasingly becoming a public health concern and is now recognised as one of the major cause of disability, medical expenses and preventable death. The aim of the study was to assess the potentials of fingerprint profile (pattern and ridge density) and digit ratio (2D:4D) in screening bronchial asthma patient (BAP). The study was conducted in Murtala Muhammad Specialist Hospital. Subjects were selected using a systematic random sampling. Using a Cochrane formula, a sample size of 140 asthmatics (male = 30, female =110) and 140 controls (male = 60, female = 80) were used. The age range is 19 – 80 years, with mean age of 42±15 years. The fingerprints were captured from the ten digits using live scan for both groups. The lengths of the second(2D) and fourth(4D) digits of both hands were measured from proximal crease to the tip of the digit using a digital Vernier caliper and the 2D:4D was calculated from the digit length. Chi- square test, two sample T-test, Mann whitney U-test and ROC analysis were used for the statistical analyses. The measurement error was assessed using the intraclass correlation coefficient ICC(r) and was found to be 0.996 and 0.926 for digit length and ridge density respectively. A significant difference (P=0.019) was observed in the left index digit pattern with BAP having lower frequency of ulnar loop and arch, and higher frequency of radial loop and whorl than control. A significant mean difference in all the digit lengths were observed, with BAP having a shorter digit length than the control; however, no difference was seen in the 2D:4D. A higher ridge density was observed among BAP than control with a significant difference in the ulnar ridge density of the left little (P=0.003) and ring (P=0.034) digit. A significant difference (P =0.025) was observed in the ridge density asymmetry of the little digit with a higher mean asymmetry among control. The left little ulnar ridge density is the best discriminator between BAP and control (AUC= 60%, P=0.003). In conclusion, the fingerprint pattern, digit length, and the ridge density hold potential as a tool for predicting Bronchial Asthma.

LIST OF ABBREVIATIONS

AFRC: Absolute finger ridge count

AFIS: Automatic fingerprint identification system

ALS: Amyotrophic lateral sclerosis

AUC: Area under the Curve

BAP: Bronchial asthma patient

CAD: Coronary artery disease

ER: Oestrogen receptor

FA: Fluctuating asymmetry

FBI: Federal bureau of investigation

FEV: Forced vital capacity

FE: Foetal oestrogen

FP: fingerprint pattern

FT: Foetal testosterone

FVC: Forced vital capacity

GINA: Global initiative for asthma

HSD: Hydroxysteroid dehydrogenase

ICC: Intraclass correlation coefficient

ISAAC: International study on asthma and allergies in childhood

IgE: Immunoglobulin E

IgG: Immunoglobulin G

IL 13: Interleukin 13

LABA: Long acting beta blocker

LTRA: Leukotriene receptor antagonist

MAA: Mean absolute asymmetry

MDA: Mean directional asymmetry

MI: Myocardial infarction

MMSH: Murtala muhammad specialist hospital

NAEPP: National asthma education and prevention program

NHIS: National health insurance scheme

NIDDM: Non-insulin dependent diabetes mellitus

OPD: Outpatient department

ROC: Receiver operator characteristics curve

SD: Standard deviation

SWGFR: Scientific working group on friction ridges

TFRC: Total finger ridge count

TGF: Transforming growth factor

CHAPTER ONE

1.0 INTRODUCTION

1.1 BACKGROUND OF THE STUDY

Asthma can be defined as a heterogeneous disease, usually characterised by chronic airway inflammation. It is defined by the history of respiratory symptoms such as wheeze, shortness of breath, chest tightness and cough that vary over time and in intensity, together with variable expiratory airflow limitation (Global initiative for asthma , 2016). Asthma arises from a complex interaction of genetic and environmental factors. Airway inflammation occurs when genetically susceptible individuals are exposed to certain environmental factors. However, the exact processes underlying asthma may vary from patient to patient (Rees, 2005).

Fingerprint simply refers to an impression left by the friction ridges of finger tips (SWGFR, 2012). Fingerprint as one of the dermatoglyphics has sparked serious interest in the field of medicine and genetics as a form of simple, non-invasive, and inexpensive ways of diagnosing patients with diseases (Amrut , Mahajan, & Gour, 2011). Cummins and Midlo (1943) used fingerprint parameters as a diagnostic aid in medical diseases. Since that time, it has become a valuable tool in anthropological, genetic, and medico-legal studies. Pattern of dermatoglyphics have been studied in certain diseases like hypertension, diabetic mellitus (Ravindranath, Joseph, Bosco, & Balasubramanyam, 2005), Schizophrenia (Mellor, 1992), psychosis (Sukanta *et al*., 2003), Carcinoma of the breast (Prashant & Fatima, 2006) and some congenital conditions like Down's syndrome, Klinefelter's syndrome, Turner's syndrome etc (Sandeep, Pakhale, Bharat, Vijay, & Megha, 2012). Dermatoglyphics and bronchial asthma are both genetically determined. Hence, the need for accessing the relationship

between certain fingerprints parameters and bronchial asthma. This may assist in predicting the occurrence of bronchial asthma among relatives of patients suffering from the disease. Thus, the fingerprint pattern can act as an anatomical feature in assessing the risk of developing bronchial asthma, which can facilitate early detection and management of the disease (Sandeep *et al.*, 2012).

Mayhew, Gillam, McDonald, & Ebling (2007) described the digit ratio as the ratio of the lengths of different digits or fingers typically measured from the midpoint of bottom crease (where the finger joins the hand) to the tip of the finger. It has been suggested by some scientists that the ratio of two digits in particular, the index finger(2D) and ring finger(4D), is affected by exposure to androgens, e.g., testosterone while in utero and that this 2D:4D can be considered a measure for prenatal androgen exposure, with lower 2D:4D pointing to higher prenatal androgen exposure (Zheng , Zhengui, Cohn, & Martin, 2011). 2D:4D has been linked to certain diseases such as coronary artery disease (CAD) (Xing-li *et al*., 2013), hypertension (Ravinder & Manju, 2016), amyotrophic lateral sclerosis (Parkin & Pamphlett, 2017), where a positive association was reported. It was speculated in certain studies that the patterns of digit formation may be associated with lung development and airway physiology (Ho-Kee, Sang, Jin, Tae, & Park, 2014).

1.2 STATEMENT OF RESEARCH PROBLEM

The prevalence of bronchial asthma has increased significantly because of the and is now recognised as a major cause of disability, medical expenses, and preventable death (Lieberman, 1999). Previous studies on relationship between fingerprint and asthma focus on the fingerprint pattern and ridge counts (Amrut *et al*., 2011; Sandeep *et al*., 2012). However other parameters such as pattern concordance and discordance,

ridge density and asymmetry received less attention in the literature. There is also paucity of data on the relationship between fingerprint variables and bronchial asthma in our locality. The 2D:4D has been linked to genetically determined conditions such as CAD, hypertension, and diabetes mellitus (Ho-Kee *et al*., 2014), however there is lack of data that links the 2D:4D with other genetically determined diseases including asthma.

1.3 JUSTIFICATION AND SIGNIFICANCE OF THE STUDY

There is a need for a simple, accurate and non-invasive screening tool for diagnosing asthma. This study provides a baseline data of fingerprint and digit ratio profiles of asthmatic patients in this population. The fingerprint and digit ratio demonstrated potential in early prediction of bronchial asthma patient. The finding of this study may also serve as an alternative means of screening of bronchial asthma by the clinicians in a resource limited environment.

1.4 AIM AND OBJECTIVES

1.4.1 Aim

The aim of the study was to determine the potentials of fingerprint profile (pattern and ridge density) and digit ratio (2D:4D) in screening of bronchial asthma patient (BAP) attending MMSH.

1.4.2 Objectives

The objectives of the study were to;

i. compare the fingerprint pattern, digit (second and fourth) length and 2D:4D between control and BAP attending MMSH

ii. investigate the differences in the level of fingerprint pattern concordance and discordance between control and BAP attending MMSH
iii. determine the difference in fingerprint ridge density and its asymmetry between control and BAP attending MMSH
iv. determine the cut-off value of ridge density, digit length and 2D:4D that discriminate between control and BAP attending MMSH

1.5 HYPOTHESIS

There is a difference in fingerprint variables (pattern and ridge density) and 2D:4D between BAP and control.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 ASTHMA

2.1.1 Overview

Asthma is among the commonest chronic disease worldwide and one of the most common chronic disease in childhood. Bronchial asthma is a chronic inflammatory disease of the airway characterised by airway hyper-responsiveness leading to airway resistance which is associated with widespread but variable, airflow limitation that is reversible either spontaneously or with treatment (Bateman , Hurd , Barnes, Bousquet, & Drazen, 2008). Asthma symptoms include intermittent attacks of wheezing, breathlessness, chest tightness and cough that occur more at night and / or early in the morning. There is often bronchoconstriction without any known precipitating factor in some situations. However, some provoking agents of the airway obstruction may be specific (antigen- antibody reaction) or non-specific stimuli (exercise, emotional stress, cold air or pharmacological agents as histamine or metacholine (Bateman *et al.*, 2008).

Its diagnosis is usually based on the pattern of symptoms, response to therapy over time and spirometry (Singh, Kumar , & Chaware , 2016). Bronchial asthma is also influenced by genetic factors. Many members of a family can be affected by the disease. Various diagnostic criteria are available for the diagnosis of bronchial asthma. However, despite the advances in medical diagnostic procedures, the diagnosis of bronchial asthma is quite difficult. This could be due to the fact that patient with asthma present with a wide spectrum of signs and symptoms which vary significantly amongst patients and from season to season (Amrut *et al.*, 2011).

2.1.2 Development of Respiratory System

The respiratory system development begins at about 4th week and proceeds into childhood. It starts with the posterior invagination of ectodermal tissue in the anterior portion of the head region, forming olfactory pits, which later fuse with endodermal tissue of the early pharynx. Concomitantly, a protrusion of endodermal tissue extends anteriorly from the foregut, producing a lung bud, which continues to elongate until it forms the laryngo-tracheal bud. The proximal portion of this structure will mature into the trachea, whereas the bulbous end will branch to form two bronchial buds. These buds then branch repeatedly, so that at about16th week, all major airway structures are present. Development progresses after 16th week as respiratory bronchioles and alveolar ducts form, and extensive vascularization occurs. Type I alveolar cells also begin to take shape. Type II pulmonary cells develop and begin to produce tiny amounts of surfactant. As the foetus grows, the respiratory system continues to expand as more alveoli develop and more surfactant is produced (Rees, 2005). From 36th week and lasting into childhood, alveolar precursors mature to become fully functional alveoli. At birth, compression of the thoracic cavity forces much of the fluid in the lungs to be expelled. The first inhalation inflates the lungs. Foetal breathing movements begin around 20th or 21th week and occur when contractions of the respiratory muscles cause the foetus to inhale and exhale amniotic fluid. These movements continue until birth and may help to tone the muscles in preparation for breathing after birth (Rees, 2005).

2.1.3 Role of Sex Hormones in Airway Development

Sex hormones exert regulatory effects on human lung development before and during the neonatal period. The androgen receptor is expressed in mesenchymal and epithelial cells of the lung throughout the human lifespan, and branching

morphogenesis of the human lung may be regulated in part by androgen (Kimura, Suzuki , Kenoko, Darnel, & Akahira, 2003). The Hox gene is essential for normal development of the embryonic body plan. Several Hox genes are expressed at different points in time in the developing and adult lung (Krumlauf, 1994). Furthermore, study showed that Hox genes control the development of digits as well as the differentiation of testes and ovaries, and that the 2D:4D might be related to Hox gene expression (Zakany, Formental , Warot, & Duboule, 1997).

Several experimental studies have been done on animals to understand lung development, physiology, and pathophysiology, and many of these studies have revealed sexual dimorphism in various aspects of these processes (Nielsen, Zinman, & Torday, 1982; Carey, Card, Germolec, & Korach, 2007) It is well established in many species that lung maturation, as measured by surfactant production, is delayed in male foetuses compared with female foetuses (Torday & Dow, 1984). It was suggested a study that the presence of higher levels of androgens in male foetuses underlies this sex difference (Nielsen *et al,* 1982).

Androgen receptors which is responsible for mediating androgen effects, are present in both male and female lungs ; and in the developing lung, there is active androgen metabolism where androgen synthesis and inactivation take place (Provost, Blomquist, Drolet, Flamand, & Tremblay, 2002). In mouse, many of the genes involved in androgen metabolism are regulated specifically on gestational day 17.5, which coincides with the emergence of mature type II alveolar cells, which are responsible for biosynthesis of surfactant (Provost & Tremblay, 2007). Synthesis and inactivation of 5-dihydrotestosterone, the most potent androgen, occur through 5-reductase and 3-hydroxysteroid dehydrogenase (HSD) activity, respectively. Provost

and Tremblay (2007) documented that expression of 3-HSD increases markedly on gestational day 17.5 when the maturation of alveolar type II cells occur, and their results suggest that 3-HSD RNA could be a reliable marker of lung maturity in foetuses. Dammann *et al*., (2000) investigated some of the signalling pathways involved in androgen regulation of foetal mouse lung development. They found that chronic androgen treatment down regulates epidermal growth factor receptor activity and up regulates transforming growth factor (TGF) - receptor activity, leading to an inhibition of surfactant protein gene expression in type II alveolar cells. Sex differences in alveolar type II cell maturation are also associated with differential expression of a variety of other genes relevant to development and surfactant production, including genes encoding apo-lipoproteins that are involved in lipid transport (Michelle, Jeffrey, James, Dori, & Kenneth, 2007).

Some studies have shown that foetal plasma levels of oestrogen are in abundance in the latter stages of gestation in many species. Maternal administration of oestrogen accelerates lung maturation and stimulates surfactant production in the foetal rabbit and rat (Gross, Wilson, Ingleson, Brehier, & Rooney, 1979 ; Possmayer *et al*., 1981).

2.1.4 Prevalence of Asthma

Asthma affects about 300 million people world-wide (Masoli, Fabian , Holt , & Beasley, 2004). Although studies on the prevalence of asthma have consistently shown lower level in rural areas, available data suggest increase in prevalence both in the rural and urban communities (Gregory, 2017 ; Masoli *et al*., 2004).

The prevalence of asthma in African Adolescents in an international study on asthma and allergies in childhood (ISAAC) which was conducted with the sole aim of having a global comparison of asthma symptoms in various region of the world was

estimated to be approximately 14% with variability by country as follows: South Africa 20.3%, Kenya 15.8%, Nigeria 13.0%, Tunisia 11.9%, Morocco 10.4% , Ethiopia 9.1% and Algeria 8.7% (Beasley, 1998). Study have shown that asthma is frequently undiagnosed in African children and when diagnosed, the disease is severe. It was suggested that poor access to healthcare facilities, sub-optimal treatment, environmental exposure, or gene-environment interaction are contributing factors. However, the wide variation in the prevalence and severity of asthma is partly explained by poverty, climate, smoke and tobacco exposure, air pollution, helminthic infection, chemical irritants, diet and exposure to allergen such as house dust mites, cockroach, dog and cat dander and washing soap. Sensitization to pet allergy, which was uncommon year back, is becoming more frequent in urban areas (Faniran, Peak, & Woolcock, 1999) . Studies conducted across Nigeria estimate the prevalence of asthma in childhood to range from 5.12-18.6% (Faniran, Peak, & Woolcock, 1999 ; Falade, Olawuji, & Osinusi, 2004). However in adult and adolescent the overral pooled estimate was 10.2% with 95% Confidence interval of 7-13.4%) (Musa & Aliyu, 2014).

2.1.5 Risk Factor of Asthma

Asthma is associated with various risk or precipitating factors. Atopy, which is a genetic predisposition to development of IgE- mediated response to common environmental, has been the strongest risk factor. Viral infection especially Rhinovirus C has been found to be implicated in triggering asthma. Other triggers include damp mouldy bedroom, household pets, cigarette smoke, mosquito coil, house dust mites (dermatophagoides pteronyssimus), feathers, dog hair, cat fur, and grass and flower pollen (Gregory, 2017). Obesity and lower socioeconomic status were also found to be among the risk of developing asthma (Zhang *et al*., 2010).

2.1.6 Asthma and Genetics

Multiple causes are associated with syndrome of asthma. For children and young adult, asthma is mostly associated with allergies (atopic asthma) which are usually hereditary, but the asthma that comes later in life is mostly due to environmental factor and are commoner in women and among smokers. There is also another variant of asthma which may occur in the presence of severe disease with sudden intractable episode of bronchospasm. Atopic asthma is the most prevalent form of the disease (Cookson, 1999).

Asthma strongly runs in families and half of the cause is genetic and half is due to environmental factor (Palmer *et al*., 2000). The strong familial tendencies associated with asthma had led to research into the genetic predisposition of the disease. Five asthma gene or genes complex have now been identified by positional cloning, which is systematic disease gene identification by finding genetic regions co-inherited with disease. The functions of all these genes are not well known. Majority of the genes identified by candidate genes studies exert their effect on the mucosal cell. These include the interleukin -13 (IL13) which increase mucus production, modifies the allergic trigger on mast cells, and microbial pattern recognition receptors of the innate immune system (Cookson, 2004). It was suggested that airway epithelial barrier and its reaction to the microbial environment are the most element in the pathogenesis of bronchial asthma (Cookson, 1999).

2.1.7 Pathophysiology of Asthma

The pathophysiology of asthma is complex and encompasses inflammation of the airway, intermittent airway obstruction (due to airway oedema and excessive mucus secretion) and bronchial hyper responsiveness (Busse, Calhoun, & Sedgewick, 1993).

The process of inflammation in asthma may be classified as acute, sub-acute or chronic. Varying degrees of mononuclear cells and eosinophil infiltration, hyper secretion of mucus, desquamation of the epithelium, hyperplasia of the smooth muscles, and airway remodelling are present (Busse, Calhoun, & Sedgewick, 1993). The presence of airway inflammation is present even in the presence of mild symptoms. The inflammatory process involves many cell type such as mast cell, eosinophils, epithelial cell, macrophages and activated T lymphocytes (regulate the process of inflammation through the release of cytokines). Other constituent airway cells, such as fibroblasts, endothelial cell and epithelial cells are responsible for the chronicity of the disease. Adhesion molecules like integrin and selectin are also important in directing the inflammatory changes in the airway (Horwitz & Busse, 1995). This inflammatory response developed over hours and is important in later and more persistent development of bronchial obstruction. The eosinophil is an important cell in this process as are pro-inflammatory cytokines generated from activated lung mononuclear cells. The consequence of this multiple cell, multiple pro-inflammatory product interaction forms the basis for the establishment of self-perpetuating, redundant process by which asthma severity increases (Busse, Calhoun, & Sedgewick, 1993).

Airway hyper responsiveness or bronchial hyperactivity in asthma is exaggerated response to numerous exogenous and endogenous stimuli. The mechanism involves direct stimulation of bronchial smooth muscle and indirect stimulation by pharmacologically active substance from mediator secreting cells such as mast cells or non-myelinated sensory neurons. The degree of airway hyper responsiveness correlates with the clinical severity of asthma (Sear, 2000).

Airflow obstruction can be caused by a variety of changes which include acute bronchoconstriction, airway oedema, chronic mucus plug formation and airway remodelling. Airflow obstruction causes increase resistance to airflow and decrease expiratory flow rate (Sear, 2000).

2.1.8 Sex Hormones and Allergic Diseases

It has long been proposed that female hormones (oestrogen and progesterone) plays a significant role in allergic diseases, evidenced by the disproportionately higher incident rate and severity of allergic disease in females compared to male (Rana & Terumi, 2013).

Several studies have reported an increased susceptibility to allergic airway disease in female mice compared with male mice (Corteling & Trifilieff, 2004; Hayashi , Adachi, Hasegawa, & Morimoto, 2003; Possmayer *et al*., 1981). Corteling & Trifilieff (2004) reported a high serum IgE in allergic female mice compared with male mice and that female mice were less sensitive to the therapeutic effects of the steroid Budesonide. Similarly, Seymour *et al*. (2002) reported significantly greater levels of total and ovalbumin-specific IgG1 and IgE in the serum of allergic females compared with allergic males. Hayashi , Adachi, Hasegawa, & Morimoto (2003) reported less severe bronchial-bronchiolar inflammation in allergic males compared with allergic females. Following castration, males were similar to females, suggesting a protective role for androgens in the development of allergic airway disease.

Treatment of female rats with the selective oestrogen receptor modulator tamoxifen also blunted the development of allergic airway disease. In addition, administration of exogenous progesterone accentuated allergic airway disease in mice (Helling *et al*., 2003). Oestrogens exert most of their effects through oestrogen receptor (ER) or

progesterone receptor (PR), and both nuclear receptors are expressed in the lung. The protective effects of oestrogen on lung injury after trauma or haemorrhage were mediated via ER and through ER-induced down regulation of inducible nitric oxide synthase. Oestrogen influence the immune cells by promoting Th2 polarisation, encouraging switching of B cell to IgE and prompting mast cell and basophil degranulation (Rana & Terumi, 2013). Evidence has shown that not only endogenous oestrogen but also exogenous compounds with estrogenic activity (xenoestrogen) may also play a role in asthma and other atopic diseases. Hormone replacement therapy was found to increase the risk of asthma onset in postmenopausal women (Dratva, 2010).

2.1.9 Sex and Age Effects on Asthma

The prevalence of asthma was found to be higher in boys as compared to girls during the prepubescent age, the trend reverses after puberty. The prevalence, severity and rate of exacerbation and hospitalisation, physician visit and deaths due to bronchial asthma are constantly higher in females than males during early and mid-adulthood. Early menarche has been proposed to be a risk factor for asthma in adult females. It was found to be associated with wheezing and multiple symptoms of asthma by decreasing the forced expiratory volume in 1 s (FEV1) and forced vital capacity (FVC) (Macsali, Gomez, & Plana, 2011).

2.1.10 Diagnosing Asthma

The diagnosis of asthma is based on clinical evidence of airway obstruction manifesting as variable respiratory symptoms (recurrent/episodic wheezing, breathlessness, cough, and/or chest tightness), physiological parameters (forced expiratory volume in 1s or peak expiratory flow), history of atopy (allergic rhinitis,

conjunctivitis, eczema) or a family history of atopy and bronchial hyper-responsiveness (Gregory, 2017). Physical examination in individuals with asthma is often normal in between attack, but the most common finding is wheezing on auscultation especially on forced expiration. However, in patient with chronic asthma, widespread wheeze could be detected despite regularity on anti-asthmatic drugs. Furthermore, patient with severe attack may develop sign of respiratory distress; cyanosis and wheezing may be absent (Global initiative for asthma , 2016).

Spirometry with post bronchodilator response is the primary test for establishing the diagnosis of asthma. Exercise spirometry is the standard method for assessing patients with exercise induced bronchospasm. Other investigations are supportive: pulse oximetry - use to exclude hypoxemia in acute asthmatic attack; Chest radiograph which is normal most of the time or may show hyperinflation (Busse, Calhoun, & Sedgewick, 1993).

Updated guidelines from the National Asthma Education and Prevention Program (NAEPP) highlight the importance of accurately diagnosing asthma, by establishing the following: Presence of episodic symptoms of airflow obstruction; airflow obstruction or symptoms which are at least partially reversible and exclusion of alternative diagnoses (NAEPP, 2007).

The updated guidelines are emphasising on the importance of asthma control. Asthma control is the degree to which the manifestation of asthma is minimised by therapeutic intervention and the goals of therapy are met. The variability of asthma makes it necessary to highly monitor the level of control on periodic basis to determine whether therapy should be maintained or adjusted. On the other hand, asthma severity is the intrinsic intensity of the disease process, and directly measured in a patient not

receiving long term control therapy. For managing asthma, the recommendation is to assess severity to initiate therapy and assess control to adjust therapy (NAEPP, 2007).

The 2007 NAEPP asthma management guidelines classified asthma into: intermittent asthma, mild persistent asthma, moderate persistent asthma and severe persistent asthma.

Intermittent asthma is characterised by: Symptoms of cough, wheezing, chest tightness, or difficulty in breathing less than twice a week; Flare ups are brief, but intensity may vary; Night time symptoms less than twice a month; no symptoms between flare-ups; Lung function test is FEV1 is 80% or more above normal values and the Peak flow has less than 20% variability am-to-am, am–to–pm, day to day. In this case reliever medication (short acting beta 2 agonist) rather than controller medication is indicated (NAEPP, 2007).

Mild persistent asthma is characterised by: symptoms of cough, wheezing, chest tightness, or difficulty in breathing 3-6 times a week; flare-ups affect activity level; night-time symptoms 3-4 times a month; Lung function test FEV1 is 80% or more above normal values; peak flow has less than 20-30% variability. Management entails: Controller medication – low dose inhaled corticosteroid preferred. Alternatives include cromolyn, leukotriene receptor antagonist (LTRA), or theophylline (NAEPP, 2007).

Moderate persistent asthma is characterised by: Symptoms of cough, wheezing, chest tightness, or difficulty in breathing daily, Flare-ups affect activity level; Night-time symptoms five or more times a month; Lung function test FEV1is above 60% but below 80% of normal values and peak flow has more than 30% variability. Management entails: combination therapy of controller medication (inhaled medium

dose corticosteroid is preferred) plus a LABA (long acting ß$_2$ agonist). Alternatives include an inhaled medium dose corticosteroid plus either an LTRA or theophylline (NAEPP, 2007).

Severe persistent asthma is characterised by: Symptoms of cough, wheezing, chest tightness, or difficulty in breathing that are continual; frequent night-time symptoms; Lung function test FEV1is 60% or less of normal values; peak flow has more than 30% variability. Management entails Inhaled high dose corticosteroid plus long acting ß$_2$ agonist (LABA) ± oral corticosteroid (NAEPP, 2007).

However, the 2016 global initiative for asthma (GINA) categorised asthma severity into mild, moderate, and severe based on the level of treatment required to control symptoms and exacerbation (Global initiative for asthma , 2016).

Various diagnostic criteria are available for the diagnosis of bronchial asthma. Despite the advances in medical diagnostic procedures, the diagnosis of bronchial asthma is quite difficult. This could be due to the fact that patient with asthma present with a wide spectrum of signs and symptoms which vary significantly amongst patients and from season to season. So, to assist in diagnosing bronchial asthma, dermatoglyphic pattern may prove an immense help (Amrut , Mahajan, & Gour, 2011).

In a quantitative study done by Amrut , Mahajan, & Gour (2011) on the dermatoglyphic patterns in patients of bronchial asthma, a higher value of a-b ridge count had been seen in patient with bronchial asthma as compared to the control group. Moreover, Singh *et al.* (2016) observed a significant decrease in arches pattern and an increase in ulnar loop pattern in patients with bronchial asthma as compared to

control. However, no significant difference was reported in the mean values of the TFRC and AFRC, and whorl pattern between BAP and controls.

2.2 FINGERPRINT

2.2.1 Ridge Characteristics and Features

Fingerprints, as well as palm prints and footprints, are made up of friction ridges, which is defined as "a raised portion of the epidermis on the palmar or plantar skin, consisting of one or more connected ridge units (SWGFR, 2012). Friction ridges are minute, raised areas of skin pushed up through the layers of the epidermis to the skin's surface. Though friction ridges all appear to be of the same width and height, they are extremely variable. It is not easy to see these variations with the naked eye (Daluz, 2015).

Fingerprint has two structural characteristics necessary for comparison and identification. They are:

Class characteristics – features that placed an individual or object in a group or subcategory. Examples; patterns type (arches, loop, and whorl), presence of creases and scars, the ridge count of a loop, and the whorl tracing of a whorl pattern and;

Individualizing characteristics that is minutiae (minute details) - features that are unique to one particular person. There are three Major types of fingerprint minutiae: bifurcations, ridge endings, and dots. Minutiae are best observed under magnification.

A bifurcation occurs when one friction ridge splits into two friction ridges like a fork in a road.

A friction ridge may end abruptly, forming an ending ridge. A friction ridge may be short, rather than continuous, with an ending ridge on each end. This is known as a short ridge.

The third type of minutiae is the dot, which appears as a dot between two friction ridges. It is the shortest possible ridge (Daluz, 2015).

Both the class and individualising characteristics are necessary in order to arrive at a conclusion. (Galton , 1892).

Two main premises form the basis for the science of fingerprint identification: Fingerprint is unique, and the fact that fingerprint is permanent. Uniqueness means that there are no two individuals in the world with the same fingerprints. Even identical twins, with identical DNA, have different fingerprints. This is because several factors are associated with the development of fingerprint. These include genetics, epigenetic factors (nutrition, position of the foetus in the intrauterine environment, external environment, etc.), growth stresses, volar pad topography (thickness, height, width, and contour), compression due to volar pad regression, bone formation and morphology, the timing and rate of ridge maturation, and the presence of vessel–nerve pairs in the dermal papillae (Muller, 1996). It is a well-known fact that fingerprints are unique because of the inherent randomness of nature. Throughout the history of fingerprint identification, it has been widely accepted that no two individual have the exact same fingerprints. Permanence means fingerprint configuration do not change throughout individuals' lifetime. They form *in utero* from the deepest layer of the epidermis and do not change as you age (Daluz, 2015).

The three basic dermatoglyphic landmarks which are found in fingerprint patterns are:

- The triradius: formed by the confluence of three ridge systems

- The core: approximate centre of the pattern
- The radiant: ridges that start from the triradius and enclose the pattern area (Cummins & Midlo, 1943).

Other parameters include:

- Finger ridge count**:** indicate the pattern size. It is defined as the number of ridges that intersect or touch the line drawn from the easily recognisable triradius point (where the three ridges meet) to the centre (core) of the pattern. The ridges are counted along a straight line which connects the triradial point to the point of the core (Sandeep, Megha, Bharat, Megha, & Viyaj, 2012). A simple loop is characterised by single triradius, whorls have two triradii yielding two counts, while simple arches have no true triradii, resulting in a zero count (Cummins & Midlo, 1943).
    - Total finger ridge count: when the ridge count is used as a measure of a maximum pattern size on the finger, only the largest count from each finger is scored, and their sum is defined as the total finger ridge count (TFRC).
    - Absolute finger ridge count: sum of all counts on all ten fingers. It is the measure of the total pattern size (Cummins & Midlo, 1943).

TFRC and AFRC are highly heritable, and the ridge pattern is genetically determined. The ridge patterns are clinically significant because they are affected by certain abnormalities of early development including genetic disorders (Singh *et al*., 2016).

2.2.2 Development of Fingerprint

Friction ridge skin forms in the fetus within the first two trimesters of human development. The sequence of the stages of development is set, but there can be individual variation of the duration of each stage. So also, the processes may overlap, creating even more variation. The process starts with the development of the fetal hand around 6 weeks after the egg is fertilized. Between 6^{th} and 7^{th} weeks' gestation, the paddle-like hand of the fetus begins to resemble a hand with fingers. The webbing initially seen between the fingers begins to dissipate. Swellings called volar pads grow on the fingertips and palmar areas of the developing hand. Volar pads continue to grow between 6^{th} and 10^{th} weeks of human fetal development. They start to vary in position, size, and shape. Around the 10^{th} or 11^{th} week, the volar pads begin to recede or deflate. This initiates the development of primary friction ridges (Wertheim, 2011). During the process of volar pad recession and friction ridge development, the epidermal layers begin to form and thicken. Around the 14^{th} and 15^{th} week, sweat glands form and coil up deep within the deeper layers of the dermis, the thicker layer of tissue below the epidermis. The sweat glands are connected to the surface where they will expel sweat through pores spaced along the fingerprint ridges. The cells that will form the primary ridges, those that we can easily see on our fingers and palms, start to differentiate in the deepest layer of the epidermis, the basal layer. This is where the initial formation of friction ridges takes place (Babler, 1987).

Ridges begin to form in different areas of the receding volar pad and spread out to eventually join and form the patterns and minute details. Friction ridge formation is affected by the growth stresses of the changing skin surface. As volar pads recede, and the skin stretches and compresses. Friction ridges develop at right angles to the plane of growth stresses and compression forces in the receding volar pad. Primary

ridges will continue to form and push up through the epidermal layers to the surface until around the 17th week of prenatal development. Between weeks 15 and 17, secondary ridges begin to form (Babler, 1987).

Secondary ridges are minute ridges that form in the furrows, or valleys, between primary friction ridges. They are found between every primary ridge deep in the epidermis, but contain no sweat glands. Secondary ridge formation signals the end of primary ridge formation. Friction ridges do not develop only on the fingers, but also spread out across the surface of the palm, finger joints, feet, and toes, though the friction ridges on the feet lag behind those on the hand by about first week (Muller, 1996). Dermal papillae also form around this stage of development between the primary and secondary ridge structures. At around 19th or 20th week, primary ridges are completed and can be seen on the surface of the skin. By 25th week, friction ridge formation is complete. The permanent patterns of these mature friction ridges are the fingerprints the fetus will have throughout its adult life (Wertheim, 2011).

2.2.3 Biological Uniqueness

Fingerprints are incredibly unique. There are no two individuals with the same fingerprints anywhere in the world. Minute differences between similar biological entities are due to the complex biochemical processes that create every cell of every organism (Claverie, 2001). There are many factors of friction ridge development that contribute to their uniqueness. These factors include genetics, epigenetic factors (nutrition, position of the foetus in the intrauterine environment, external environment, etc.), growth stresses, volar pad topography (thickness, height, width, and contour), compression due to volar pad regression, bone formation and morphology, the timing and rate of ridge maturation, and the presence of vessel–nerve pairs in the dermal papillae. Many of these processes also contribute to the formation

and locations of minutiae (Muller, 1996). Furthermore, considering a total of 20,000–30,000 genes in the human genome and that many factors control how each of those genes is expressed, it is easy to see how nature could never repeat itself. Biological development is a unique, randomized, natural process. This is one of the basis of the premise that no two fingerprints are exactly alike, and therefore every fingerprint is unique (Claverie, 2001).

2.2.4 Fingerprint Permanence

The second premise that forms the basis for the science of fingerprint identification is the idea that fingerprints are permanent. The basal layer is the generating layer for the friction ridge patterns seen on the surface. The basal layer can be thought of as the blueprint for the building of friction ridges and the blueprint never changes. It is set for life. Every cell in the basal layer generates identical daughter cells through the process of mitosis. The science of fingerprint analysis is dependent on uniqueness and permanence (Maceo, 2011).

2.2.5 Fingerprint Pattern

As friction ridges spread out across the surface of the developing fingers, they form one of three patterns: an arch, a loop, or a whorl. Each pattern type can be broken down into several sub patterns (Babler, 1987).

The pattern formed is dependent on the dimensions of the volar pad, its size, shape, and position on the finger. Pattern type is a function of the volar pad's 3D regression combined with the proliferation of friction ridges. Since 1924, it was hypothesized that volar pad height and symmetry influence fingerprint pattern formation. High symmetrical volar pads form whorls. Asymmetrical volar pads form loops. And "low" volar pads form arches (Babler, 1987).

Most fingerprint pattern types have one or more of the following features formed as a result of ridge flow: the core (nucleus/centre) and delta (triradius). The core is the focal point around which the ridges flow while delta is an area of friction ridge skin where ridge paths flowing in three different directions create a triangular pattern (Federal Bureau of Investigation, 1987).

Fingerprint pattern of dermal ridges can be grouped majorly into three based on Henry's classification;

1. Loops (60-65%) (Robert, 1972): This is the predominant pattern type. Loops are patterns in which the ridges enter on one side of the finger, make a U-turn around a core, and exit out the same side of the finger. In other words, a loop is that type of pattern in which one or more ridges enter upon either side, recurve, touch or pass an imaginary line between delta and core and pass out or tend to pass out upon the same side the ridges entered (Federal Bureau of Investigation, 1987).

   Thus, the three requirements for a loop pattern are:

   i. A sufficient recurve
   ii. One delta
   iii. A ridge count across a looping ridge

There are two subcategories of loops: radial loops and ulnar loops. This is in reference to the bones of the forearm, radius and ulna.

Radial loops: are loops that are slanted toward the radius, the inner bone of the forearm. These loops flow toward the thumb and the triradius is on the side of the little finger for the hand in question (Daluz, 2015).

Ulnar loop: are loops that are slanted toward the ulna, the outer bone of the forearm. These fingerprints flow toward the little finger of the hand and the triradius is on the side of the thumb for that hand (Singh *et al*., 2016)

When latent, or unknown, fingerprints are collected from crime scenes or from items of evidence, it will be difficult to tell whether a finger on the right hand or the left hand made the loop pattern. In this case, the loops are refer to as either right slanted loops (also known as "right loops") or left-slanted loops (also known as "left loops") (Olsen, Charles , & Thomas, 1978).

2. Whorls: The second most populous fingerprint pattern type is the whorl, which is found in 30%–35% of fingerprints in the population. A whorl is a circular pattern. Most friction ridges in these patterns make complete circuits around a central core. Whorl patterns must have at least two deltas and a sufficient recurve in front of each delta (Federal Bureau of Investigation, 1987).

There are four subcategories of whorls: plain whorls, double-loop whorls, central pocket loop whorls, and accidentals.

a. Plain whorls are the most common type of whorl. Some plain whorls resemble targets. The core is well defined at the "bull's-eye" of the target. Some resemble elongated, concentric ellipses. A requirement for a plain whorl is that an imaginary line drawn from delta to delta must cut through at least one recurving ridge (Cummins & Midlo, 1943).
b. Double-loop whorls are technically whorl patterns, since they have two deltas, but they consist of two distinct loops curved around each other. These two intertwined loops have two distinct shoulders. Double-loop whorls are most commonly found in the thumbs (Daluz, 2015).

c. A central pocket loop whorl resembles a small whorl pattern trapped within a loop. There are, however, two deltas associated with this pattern, which is what makes it a whorl. It can be difficult to distinguish a central pocket loop whorl from a plain whorl. The difference is that in a central pocket loop whorl, an imaginary line drawn from delta to delta does not cut through a recurving ridge (FBI, 1987).

d. An accidental whorl is any combination of two distinct pattern types. This is the only pattern type in which you will see more than two deltas. Most often, this pattern displays some combination of a loop and a whorl (FBI, 1987).

3. Arches: They are the least common fingerprint pattern. They are found in 5% of fingerprints in the general population. The friction ridges enter one side of the fingerprint, make a rise in the centre, and exit out the other side of the print. There are no deltas in an arch pattern. The core is indistinct in most arches (Daluz, 2015).

There are two types of arches: plain arches and tented arches.

a. Plain arches are characterized by a smooth arching pattern with all of the friction ridges rising and falling uniformly through the pattern. It cannot have any looping ridges, recurves, or ridges angular to the wave pattern.

b. Tented arches are arch patterns that contain one or more ridges at an angle to the flow of the arch, often perpendicular to the ridges at the base of the print. Another way to describe the tented arch is "a type of pattern which possesses an angle, an up thrust or two of the three basic characteristics of the loop." An up thrust is a vertical or angular protrusion in the centre of the print that ends abruptly. A tented arch is also characterized as any pattern possessing two of

the three requirements for a loop. Thus, it appears like a loop, but it lacks either a delta or a recurve or ridge count (Daluz, 2015).

2.2.6 Fingerprint Recoding System

In order to analyse friction ridge skin, one must first record the pattern digitally or with fingerprint ink or powder. The resulting records are known as exemplars or known prints. They are also known as inked prints, record prints, or standards (Cutro, 2011).

a. Inked fingerprint record: The most common medium for recording friction ridge skin is ink which are recorded on ten print cards. Each finger is rolled in ink and subsequently rolled into the corresponding box on the ten-print card. The finger is rolled from "nail to nail" to capture the entire friction ridge surface. This means the finger must be rolled from one side of the finger (at the nail) all the way around to the other side of the nail. A fingerprint rolled from nail to nail should be rectangular in shape (Cutro, 2011).
b. Fingerprint powder is also used as a medium to record friction ridges. This method is quick and easy and results in high-quality major case prints. Unlike fingerprints recorded in ink, powdered friction ridges often display better detail including well-defined ridge shapes and pores. The hand is powdered and recorded on flexible, white adhesive sheets with clear acetate covers. While this method is simple and results in high-quality major case prints, the resulting record is not in the official government format required for filing or for entry into an automatic fingerprint identification system (AFIS) (Daluz, 2015).

c. Fingerprints can be recorded on a live scan device, which scans and digitizes fingerprints similar to a document scanner. This method does not require ink, powder, or any other medium to capture the print. The live scan operator, the individual taking the fingerprints, rolls the individual's fingerprints onto a plastic or glass. The live scan acquires the image and the computer processes it using a computer algorithm: a set of procedures the computer follows to process data (Cutro, 2011).

Live scan fingerprinting has several advantages over and is quickly replacing inked fingerprinting for the following reasons: first of all, live scans prints are digital and can be stored on computers rather than in large numbers of file cabinets required by manual ten print cards. Secondly, unlimited numbers of exact copies of the fingerprints can be reproduced on the computer printer. Thirdly, live scan prints can be instantly transmitted between agencies using computer networks. Furthermore, Image quality is more uniform due to the quality control standards built into the live scan device. Lastly, Live scan devices directly connect to AFIS. This makes it possible to take a person's prints; search them automatically against local, state, and national records; and get results back, often in minutes (Cutro, 2011).

2.2.7 Fingerprint Distribution and Asymmetry

The general distribution of the finger print pattern was of the order that loops were the most common pattern (56.3%), followed by whorls (39.5%) and arches (4.2%). There was a significant bimanual difference, whorls were slightly more common on the right hands. Radial loops and arches were more frequent on the left index finger than on the right one. Arches were more frequent on the left middle finger than on the right one (Muralidhar, Karumanchi, & Kolla , 2011).

Failure of identical development on both side of the body of an individual is termed asymmetry. The number of dermal fingerprint ridges on the left and right hands in humans is not identical. Eighty percent (80%) of persons have more fingerprint ridges on the right. The frequency for the minority pattern with more ridges on the left (left forward asymmetry) is higher in females. The term directional asymmetry indicates whether the ridge count is higher on the left or right hand (Richard & Robert, 1999). The different number of fingerprint ridges on the left compared to the right hand originates in the first trimester of pregnancy and remains unchanged (Babler, 1987). Fluctuating asymmetry can be defined as the random differences between corresponding characters on each side of the plane of symmetry. In practical terms, one estimates the level of fluctuating asymmetry from the differences between corresponding right and left-sided structures. These differences are zero if each side is a perfect mirror image of the other. Fluctuating asymmetry requires that the differences between the two sides to be random, that is, one side is never consistently bigger, or smaller, than the other. If the differences are consistently in the same direction, then this would be directional asymmetry. The distribution of the signed, right minus left differences, in a population sample, approximates to a normal curve with a mean of zero. The variance of this distribution curve is a measure of fluctuating asymmetry (Mellor, 1992).

Cummins & Midlo (1943) recognized asymmetry in homologous regions of fingers and palms of humans for various aspects of dermatoglyphics. Asymmetry has been attributed to environmental effects operating at early foetal life during the formation of dermal ridges. Bilateral asymmetry is a common phenomenon in nature. The degree of fluctuating asymmetry is indicative of an organism's susceptibility to developmental noise. An elevated level signifies that the organism has a low capacity

for buffering adverse environmental effects that could deflect the course of its genetically determined programme of development (Van Valen, 1962). The ridge count asymmetry and diversity among homologous as well as non-homologous fingers appears to be patterned along population lines and the investigations would provide some insight into the genetic and developmental nature of dermatoglyphics (Kusuma, Babu, & Naidu, 2001).

A study was conducted in Indian population to investigate intra-population variation (i.e. regional variation within the hand and variation between sexes) and ethnic variation in finger ridge count asymmetry. It was suggested that the underlying mechanisms influencing the level of asymmetry may be similar for all groups, and that certain dermatoglyphic areas like the thumb are more vulnerable to developmental / environmental stress, that cause asymmetry at the developmental stage. The mean directional asymmetry (MDA) and mean absolute asymmetry (MAA) were measured for homologous fingers. The asymmetry follows a decreasing trend in radio-ulnar direction with higher mean values in thumb and index finger. The individual variation is also higher in the thumb and the index fingers. However using another formula (Jantz's) of assess asymmetry ($\sqrt{A^{2)}}$) for total finger ridge count and absolute finger ridge count, no significant sexual or ethnic differences was reported (Kusuma, Babu, & Naidu, 2001).

2.2.8 Ridge Density

Ridge density (RD), defined as the number of digital ridges per unit area, varies according to sex, age, and population origin (Acree, 1999). Studies have reported that females have a significantly higher ridge density than males (Acree, 1999; Gutiérrez-Redomero, Alonso, & Dipierri, 2011). The higher ridge density in females has been

attributed to the level of ridge thickness and it is suggested that females tend to have finer epidermal ridge details. Consequently, the females have significantly higher finger ridge density than males in a given area (Gutiérrez-Redomero, Alonso, & Dipierri, 2011). It was proposed that the difference between the finger ridge density in males and females in a given area may be attributed to the fact that on an average body proportions of males are larger than females thus the same numbers of ridges are accommodated among the males in a larger surface area and thus, a lower density is observed among males. Fingerprint ridge count is controlled by polygenic inheritance and strongly inherited. Consequently, it may be assumed that given the same genetic make up, males and females should both have the same number of ridges in a fingerprint. Therefore, difference in ridge density between sexes should be correlated with other parameters such as stature and built of an individual (Gutiérrez-Redomero *et al*., 2011). It is also likely that some associated genes of dermal ridges may reside in the X chromosome. If so, then having a double dose (XX chromosomes in females) of the same feature may lead to complete/strong penetrance. There seems to be an indication that the total ridge count is influenced by the genetic component of the individual especially by the sex chromosome component. This may also be influenced by height and chromosomal abnormalities (David , 1981).

Adamu, Ojo, Danborno, & Adebisi (2018) found out that the ridge density can predict sex significantly by more than what could be observed by chance (50%) among hausa ethnic group of kano state , Nigeria.

2.2.9 Fingerprint and Other Disease Conditions

It is a well-known fact for decade that a connection exists between dermatoglyphics and certain diseases or syndromes. Certain fingerprint predominates in some diseases

than the others. In Down syndrome, radial loop in often seen in the ring and little finger unlike in general population where the radial loop is more commonly seen in the index and middle finger. Similarly in patient with Alzheimer's disease, radial loop was predominantly seen in ring and the little finger, hence supporting the association between the two diseases (Weinreb, 1985). Arches was reported to be the predominant pattern in patient with Edward syndrome (trisomy 18), and patau syndrome (trisomy 13) (Blanka & Milton, 1976), while ulnar loop was found to be the predominant pattern in Down syndrome. In addition, down syndrome patients were reported to have a single transverse palmer crease, lower ridge count especially on the little digit (Mglinets, 1991). Diabetic patients were reported to have high frequency of whorl pattern and lower frequency of arch and loop pattern (Mehta & Mehta, 2015). Moreover in hypertensive, a higher frequency of whorl was also reported together with a higher average ridge count (Buddhika, Robert, Suneth, & Thilini, 2015).

Studies have established a link between fluctuating asymmetry (FA) and risk of development of certain disease. FA was found to be significantly higher in the thumb, so also subtotal ridge count and palmer atd angle were found to be higher in female patient with carcinoma of the breast (Prashant & Fatima, 2006). In another study,the schizophrenic patient where found to have significantly higher levels of fluctuating asymmetry on four dermatoglyphic traits, the finger-ridge counts, fingerprint patterns, the palmer atd angles and palmer a-b ridge counts, than controls (Mellor, 1992). Moreover, significant higher fluctuating asymmetry were obtained for 'atd' angle, ridge count of 5^{th} finger in the male and for 2^{nd} finger in the female non-insulin dependent diabetic mellitus (NIDDM) patients. However, it was found to be low in the 3^{rd} finger in females NIDDM individuals (Ravindranath *et al*., 2005).

2.3 DIGIT RATIO

2.3.1 Concept of Digit Ratio

2D:4D is the relative lengths of the second digit (the index finger) and the fourth digit (the ring finger). It has been known for many years that 2D:4D varies according to sex, such that males tend to have longer fourth digits relative to second digits (low 2D:4D) than females (high 2D:4D) (Phelp, 1952; Manning *et al.*, 1998).

2.3.2 Digit Measurement

Various methods of measurement of the digits had been used in different studies. Brañas-Garza and Rustichini (2011) use photocopies of the right hands, Garbarino, Slonim, & Sydnor, 2011 use scans and they measure the mean of both hands. Pearson & Schipper (2012) use the scans of the right hand only. Recent studies have also reported that both hands –and not only the right one- are providing valuable information (Branas-Garza, Kovarik, & Neyse, Second to Fourth Digit Ratio Has a Non-Monotonic Impact on Altruism, 2013). In fact, endocrinology studies claim that the left hand is a more precise indicator of foetal exposure (Levent & Pablo, 2014). Since the measure depends on small units of length and is unobservable without using a measurement tool, self-reported measurements have been argued to be invalid. The other options, like direct measurement or photocopies, are also short of accuracy. Flatbed scanners are the most appropriate tools in terms of precision, practicality, and costs (Branas-Garza, *et al.*, 2013).

2.3.3 Digit Ratio and Sex Hormones

A balance of foetal testosterone (FT) and foetal oestrogen (FE) influences the formation of 2D:4D, such that low 2D:4D indicates high FT and low FE and high 2D:4D indicates low FT and high FE (Manning *et al.*, 1998).

Several studies on human lung development have indicated that in utero milieu may influence adult lung function. Sex hormones regulate human lung development before and during the neonatal period. Androgen receptors are expressed in mesenchymal and epithelial cells of the lung throughout the human lifespan, and branching morphogenesis of human lung may be regulated in part by androgens. Considerable experimental animal data suggest that sex hormones have a role in regulating lung development. Androgens have been shown to have inhibitory effects while oestrogens were found to exert stimulatory effects (Kimura, Suzuki , Kenoko, Darnel, & Akahira, 2003).

Zheng , Zhengui, Cohn, & Martin, (2011) showed that the 2D:4D is controlled by the balance of androgen to oestrogen signalling during a narrow window of digit development in a study conducted on mice. Androgen receptor activity is higher in 4D than in 2D, and inactivation of androgen receptor decreases growth of 4D, which causes a higher 2D:4D.

It is believed that unbalanced exposure to prenatal testosterone or oestrogen may be associated with the aetiology of series of phenomena and disorders including left-handedness, autism, dyslexia, migraine, stammering, ventricular septal defect, pulmonary stenosis, and patent ductus arteriosus (Nora *et al*. 1976).

Manning *et al.* (1998) suggested that the 2D:4D is a marker for testosterone and oestrogen levels towards the end of the first trimester of pregnancy. The 2D:4D may therefore be a predictor of fertility, and the pattern of differentiation of the central nervous system. During past decades, the relationship between 2D:4D and sex steroids related diseases including infertility, gastric cancer, breast cancer and prostate

cancer have been discussed in several ethnic groups (Manning & Bundred, 2000; Lutchmaya, *et al*., 2004: Ozdogmus, et al., 2010).

2.3.4 Digit Ratio and Sex

Digit ratios differ between males and females. The mean digit ratio is lower in males than females. This gender-associated difference may be due to changes in prenatal steroid concentrations. Thus, digit ratio is determined primarily during embryonic development and changes little after sexual maturation (Lutchmaya, Baron-Cohen, Raggatt, Knickmeyer, & Manning, 2004). Increase in the amounts of intrauterine testosterone relative to oestrogen is considered to be the reason for a lower 2D:4D in males. The reason for this appears to be that during development, the foetal ring finger has more plentiful androgen and oestrogen receptors than the index finger and so grows longer in the presence of a relative excess of testosterone (Manning & Bundred, 2000). A previous study reported that the digit ratio of the right hand is negatively correlated with the foetal testosterone to foetal oestradiol ratio. An elevated level of foetal testosterone relative to foetal oestradiol would therefore result in a low digit ratio (Lutchmaya *et al*., 2004). Also, Zheng *et al*., (2011) reported that the digit ratio is controlled by the balance of androgen to oestrogen signalling during digit development. Moreover, Manning *et al.* (1998) reported in Europe that the mean male 2D:4D was significantly lower than mean female 2D:4D in left-hand and right-hand 2D:4D. In accordance with the data in China, it was found out that men showed significantly smaller 2D:4D than women in right and left hands (Yang, Gray, Zhang, & Pope, 2009).

2.3.5 Digit Ratio and Lung Function

Sex and sex hormones play a key role in lung physiology. It has been proposed that the ratio of the second to fourth digits (digit ratio) is correlated with foetal sex hormones (Carey, Card, Germolec, & Korach, 2007). With respect to lung function, males tended to be superior to females with the same anthropometric characteristics. However, after controlling for lung size, female performance surpassed that of males (Schwartz, Katz, Fegley, & Tockman, 1988).

Lung morphogenesis is a highly regulated process that may be affected by the both genetic and environmental factors in utero. Importantly, all known sex steroid hormone receptors have been shown to be expressed in lung tissue. Seven sex hormones exert regulatory effects on human lung development before and during the neonatal period (Kimura *et al*., 2003).

In a study done in 2014 among adult Koreans awaiting urological surgery, a correlation between digit ratio and lung function was investigated using pulmonary function test (spirometry). It was found out that lung function was related to digit ratio, which is reflective of prenatal steroid hormone activity in an individual. Participants with a lower digit ratio tended to have decreased lung function. In males, univariate and multivariate analysis using linear regression models has shown that digit ratio was a significant predictive factor for FVC and FEV1 (Ho-Kee *et al*., 2014). The results suggest that digit ratio is related to airway physiology influenced by sex hormones, and that the in-utero milieu might impact adult lung function. Moreover, unlike in male, digit ratio, when adjusted for other factors, is not an independent predictive factor for adult lung function in women. However, significant positive correlations were clearly found between digit ratio and lung function (FEV1

and FEV1/FVC ratio) on univariate analysis using linear regression models. These results also suggest that digit ratio is related to lung function in women. However, it was observed that this relationship was modified by smoking history, as a lack of correlation between the digit ratio and adult lung function among ever smokers, unlike never smokers observed, indicates that smoking per se rather than digit ratio has a stronger relation to lung function. In general, it is well known that increasing age and smoking are major risk factors for airway obstruction. Furthermore, the study established the association between smoking, accelerated loss of lung function and Chronic Obstrucive Pulmonary Disease. (Ho-Kee *et al*., 2014).

2.3.6 Digit Ratio and Other Diseases

An association was established between 2D:4D and CAD (Kumar & Bala, 2016). Several studies have shown a significant association between 2D:4D and atherosclerotic diseases. However, Manning and Bundred (2001) found a negative relationship between 2D:4D and age at first myocardial infarction (MI), meaning men with higher 2D:4D tended to have their first MI earlier in life than men with lower 2D:4D. A study involving 50 males and 50 females in Greece reported a significantly higher 2D:4D in males with MI than the respective ratios in healthy males, but no significant differences were observed in the ratios between females with MI and healthy females. It was proposed that 2D:4D may be a useful biomarker for predisposition to MI in Greek men, but not in Greek women (Kyriakidis, Papaioannidou, Pantelidou, Kalles, & Gemitzis, 2010). Ozdogmus *et al.* (2010) reported a study of 100 heterosexual male autopsies whose mean age was 21.4 years. They found that the high 2D:4D of right hand was related to the atherosclerotic plaque development of the right coronary artery.

The 2D:4D has been reported to be lower in people with amyotrophic lateral sclerosis (ALS) than in healthy controls. This has led to suggestions that exposure to increased prenatal testosterone, which also lowers this ratio, could be a risk factor for ALS (Vivekananda, Manjalay, & Ganesalingam, 2011). This contradict the result from an international online case control study, were no significant difference was observed in the 2D:4D of patients with ALS and that of healthy control (JaneAlana & Roger, 2017).

Conversely, the 2D:4D was found to be higher among hypertensive than non-hypertensive control (Ravinder & Manju, 2016). Furthermore, previous studies have reported 2D:4D as a predictor of CAD (Manning & Bundred, 2001; Xing-li *et al*., 2013).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 STUDY SETTING

The study was conducted in Chest Speciality Clinic in Murtala Muhammad Specialist Hospital. It is a premier health institution of the state, it serves as both specialist and referral centre for many hospitals under Kano and neighbouring states. The Hospital was commissioned in 1962, presently with 862 official bed space. It has a total of 30 wards and units, nine operating theatres and 14 clinics. It has the staff strength of 1656. It is also a national health insurance scheme (NHIS) accredited hospital. It offers wide range of medical services; residency training, primary, secondary, and tertiary/specialist care (Murtala Muhammad Specialist Hospital, 2018). The Chest Clinic is run every Thursday of the week. Around 100 patients with respiratory problems (like asthma, chronic obstructive pulmonary disease, tuberculosis etc.) visit the clinic on a weekly basis.

3.2 STUDY POPULATION

3.2.1 Study Design

Cross-sectional study

3.2.2 Sampling Technique

Systematic random sampling (probability sampling) was used to select the patient and the control.

3.2.3 Sample Size Determination

$n = \frac{Z^2pq}{d^2}$ ……. (Cochran, 1977)

n = sample size

Z= 1.96 (95% confidence interval)

P = prevalence of asthma in Nigeria = 10.2% = 0.102 (Musa & Aliyu, 2014)

q= 1-p = 1 – 0.102 = 0.898

d = 0.05 (Level of precision)

$$n = \frac{(1.96)^2 \times 0.102 \times 0.898}{(0.05)^2}$$

$$n = 140$$

140 Asthmatic patients and 140 control group were examined.

3.2.4 Inclusion Criteria

- All clinically diagnosed asthmatic patients who attend the outpatient department OPD clinic during the study period were considered.
- Both sexes and age group 18years and above where considered.
- Match control were selected from among the OPD visitors attending clinic other than the Chest Clinic (i.e. those free from having any respiratory problem or asthma-like symptoms).

3.2.5 Exclusion Criteria

- Patient with respiratory problem other than asthma.
- Those not confirmed asthmatics
- Participants with family history of asthma where excluded among the control because of reported similarities of their fingerprints with asthmatics.
- Sickle cell disease patients were excluded because of reported shorter digit length.

- Participant with physical deformity that affect the fingerprint and digit

3.3 ETHICAL CONSIDERATIONS

Ethical approval was obtained from Kano State Hospital Management Board. (Ref. No MOH/Off/797/T. I/790). Patient's informed consent was also obtained prior to the study.

3.4 METHODS

3.4.1 Collection of Biodata and Medical History

The data of the participants were collected using proforma. This include patient: Bio data; age, sex, educational level, marital status, and occupation; Medical history: Duration of asthma, family history of asthma, history of allergic rhinitis and conjunctivitis (Appendix I).

3.4.2 Capturing of Fingerprints

The fingers were cleaned with spirit to remove any oil, dirt and sweat. The fingerprints were captured using digital persona by direct sensing technology (4500 Fingerprint reader, S/N AZ00T028478, China), a live scanner (Jain *et al*., 2007) (Plate I).

The print from each digit of both hands was captured for both the asthmatics and apparently healthy control.

3.4.3 Classification of Fingerprints

3.4.4 The fingerprint pattern was classified into three basic patterns: (Figure 3.1)

a. Whorl: A circular pattern. Most friction ridges in these patterns make complete circuits around a central core.

b. Arches: The friction ridges enter one side of the fingerprint, make a rise in the centre, and exit out the other side of the print. There are no deltas.

c. Loops: Loops are patterns in which the ridges enter on one side of the finger, make a U-turn around a core, and exit out the same side of the finger.

    I. Radial: These loops flow toward the thumb and the triradius is on the side of the little finger for the hand in question.

    II. Ulnar: These fingerprints flow toward the little finger of the hand and the triradius is on the side of the thumb for that hand (Cummins & Midlo, 1943).

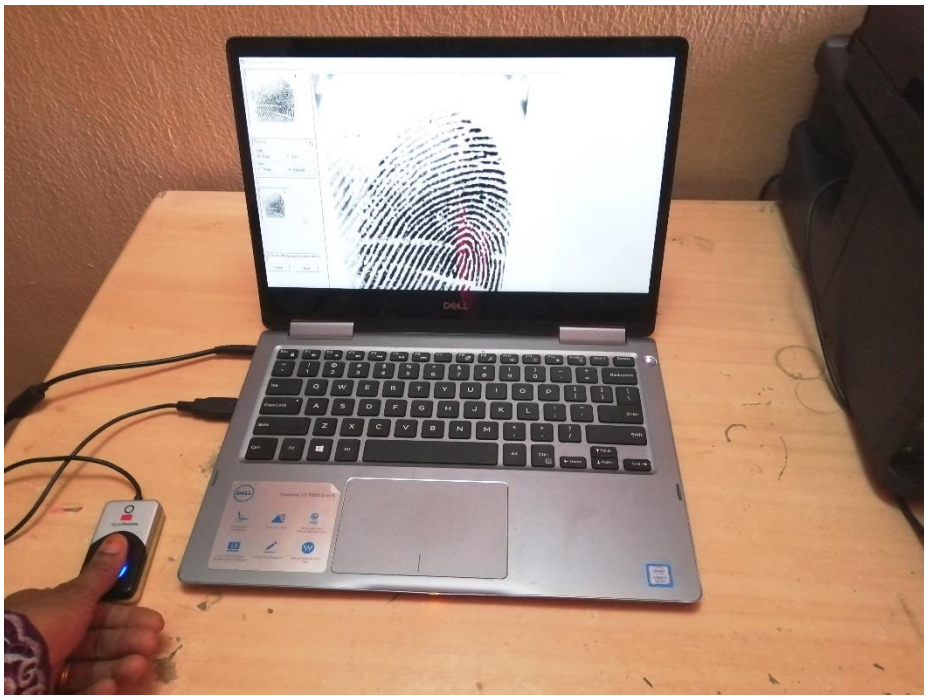
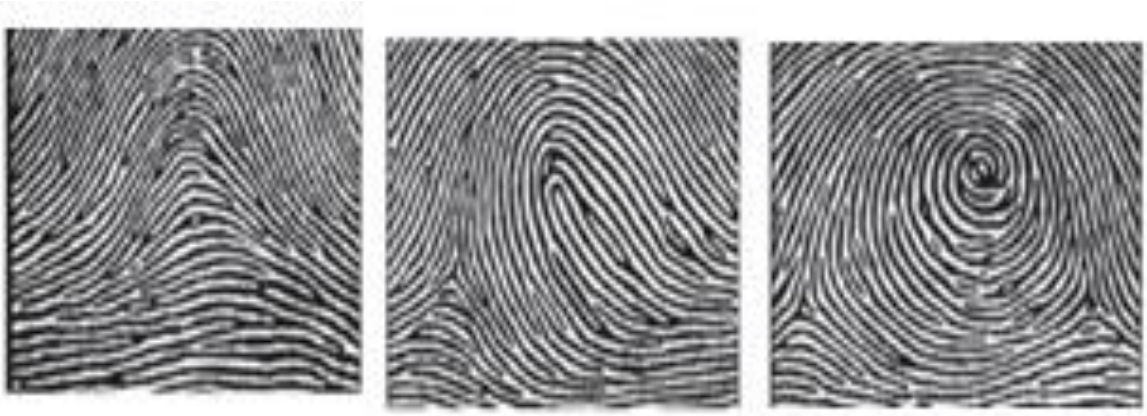


Plate I: Technique for Fingerprint Capturing



ARCH LOOP WHORL

Figure 3. 1 Three Basic Patterns of Fingerprint

3.4.5 Determination of Concordant

The pattern type concordance was calculated for the fingerprints of each left to right corresponding fingerprint pair of the participants, such that the concordance value was scored 1 if the corresponding fingerprints have the same pattern type, and is 0 if otherwise, then the sum of the 5 fingerprint pairs concordance values were then calculated. Left and right concordance and discordance was scored on a range of 0-5. For example, if only one finger on the left match that of the right, then the concordance was scored as 1 while the discordance was scored as 4 (Tadross, Badawi, Mahfouz, Jantz, & Blair, 2006).

3.4.6 Determination of the Ridge Density

The ridge density was determined by counting the number of ridges per 25mm² area. (Figure 3.2). The count was carried out diagonally on a square measuring 5 mm × 5 mm using Acree's method. The ridge density was determine for both radial and ulnar side of each digit (Acree, 1999).

3.4.7 Determination of Digit Length and Ratio

The lengths of the second and fourth digits of both hands were measured by me using a digital Vernier caliper (Tack life DC01- USAKK0110934, China) accurate to 0.01 mm placed directly on the ventral surface of the fingers, from the midpoint of crease proximal to the palm at the base of each digit to the digit tip. (Plate II). The digit ratio was calculated by dividing the length of the second digit with that of the fourth digit (Manning *et al*., 1998).

3.4.8 Determination of Bronchial Asthma

Hospital diagnosis was used in selecting patients with bronchial asthma.

Figure 3. 2 Techniques of Determination of Ulnar and Radial Ridge Density

Plate II: Technique for Measurement of 4th and 2nd digit lenght

3.5 ASSESSMENT OF MEASUREMENT ERROR

The measurement error was assessed using the intraclass correlation coefficient (r). The r was computed to demonstrate the strength of the relationship (similarities) between two measurements. The values for the reliability coefficient ranged from 0 to 1, where ICC < 0 indicated ‘‘no reliability” and 0.6 to <0.8 indicated substantial reliability, and 1 almost perfect reliability (Shrout & Fleiss, 1979). The interval between two measurements was one month and 30 randomly selected records were used for this evaluation. The r was found to be 0.996 and 0.926 for digit length and ridge density respectively, which indicate almost perfect reliability.

3.6 STATISTICAL ANALYSES

Data were expressed as frequency, mean ± SD. Chi-square test was used to compare the fingerprint pattern and concordance between control and BAP. Two sample T-test and Mann Witney test was used to analyse the difference in ridge density, asymmetry, digit length and 2D:4D between control and BAP. Receiver Operator characteristics curve was employed to discriminate between the two groups. Youden’s index (YI) was used to determine the cut-off values of ridge density and 2D:4D that best discriminate between control and BAP. Analysis was carried out using SPSS version 22. $P < 0.05$ was set as level of significance.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 RESULTS

4.1.1 Comparison of the Fingerprint Pattern, digit length and 2D:4D between Control and BAP Attending MMSH

Table 4.1 shows comparison of the fingerprint pattern between control and bronchial asthma patient (BAP) attending MMSH. It was observed that ulnar loop was the predominant pattern among all study groups followed by whorl. Whereas radial loop was the least pattern. Tables 4.2 and 4.3 show the comparison of the fingerprint pattern in the right and left digit respectively between control and BAP attending MMSH. The distribution of fingerprint patterns in all the digits shows a lower frequency of arches in BAP than control. However, in first four digits (index, middle, ring and little) a higher frequency of whorl and lower frequency of ulnar loop is seen in BAP as compared to control. Whereas in the thumb, the reverse was seen (high frequency of ulnar loops and less frequency of whorl) in BAP than control. A significant difference was observed in the fingerprint pattern of the left index digit between BAP and control (Chi^2 = 9.94, *P*= 0.019), with asthmatics having lower frequency of ulnar loop pattern (73% as compared to 78% in control) and arch (4% as compared to 15% in control), with a higher frequency of radial loop than control (4:1). It was observed also that radial loop was totally absent in the thumb of control group. However, the differences in patterns in the remaining digits were not significant. Moreover, arch pattern was seen more among controls than BAP in all the digits.

Table 4. 1: Comparison of the Fingerprint Pattern between Control and BAP Attending MMSH

		DIGITS											
Group	Fingerprint Pattern	Left index	Right index	Left little	Right little	Left middle	Right middle	Left ring	Right ring	Left thumb	Right thumb	Total	Percentage
BAP	Ulnar loop	73	72	92	98	89	86	79	66	62	58	775	55.36
	Radial loop	4	2	1	1	1	1	1	2	2	1	16	1.14
	Whorl	59	61	40	36	46	47	57	69	68	76	559	39.93
	Arch	4	5	7	5	4	6	3	3	8	5	50	3.57
Control	Ulnar loop	78	75	90	96	93	92	86	73	58	53	794	56.71
	Radial loop	1	1	2	2	2	2	1	1	0	0	12	0.86
	Whorl	46	53	39	35	35	37	46	61	74	80	506	36.14
	Arch	15	11	9	7	10	9	7	5	8	7	88	6.29

Table 4.2: Comparison of the Fingerprint Pattern of the Right Digits between Control and BAP Attending MMSH

Digits	Pattern type	BAP (expected frequency)	Control (expected frequency)	Chi^2-Value	*P* Value
Right index	Ulnar loop	72(73.50)	75(73.5)	3.21	0.361
	Radial loop	2(1.50)	1(1.5)		
	Whorl	61(57.00)	53(57)		
	Arch	5(8.00)	11(8)		
Right little	Ulnar loop	98(97.00)	96(97)	0.70	0.873
	Radial loop	1(1.5.00)	2(1.5)		
	Whorl	36(35.50)	35(35.5)		
	Arch	5(6.00)	7(6)		
Right middle	Ulnar loop	86(89.00)	92(89)	2.33	0.508
	Radial loop	1(1.5.00)	2(1.5)		
	Whorl	47(42.00)	37(42)		
	Arch	6(7.5.00)	9(7.5)		
Right ring	Ulnar loop	66(69.50)	73(69.5)	1.68	0.642
	Radial loop	2(1.50)	1(1.5)		
	Whorl	69(65.00)	61(65)		
	Arch	3(4.00)	5(4)		
Right thumb	Ulnar loop	58(55.50)	53(55.5)	1.66	0.646
	Radial loop	1(0.50)	0(0.5)		
	Whorl	76(78.00)	80(78)		
	Arch	5(6.00)	7(6)		

BAP: Bronchial asthma patient

Table 4.3 Comparison of the Fingerprint Pattern of the Left Digits between Control and BAP Attending MMSH

Fingers	Pattern type	BAP (expected frequency)	Control (expected frequency)	Chi^2-Value	*P* Value
Left index	Ulnar loop	73 (75.50)	78 (75.50)	9.94	0.019
	radial loop	4 (2.5.00)	1 (2.50)		
	Whorl	59 (52.50)	46 (52.50)		
	Arch	4 (9.50)	15 (9.50)		
Left little	Ulnar loop	92(91.00)	90(91.00)	0.62	0.892
	Radial loop	1(1.50)	2(1.50)		
	Whorl	40(39.50)	39(39.50)		
	Arch	7(8.00)	9(8.00)		
Left middle	Ulnar loop	89(91.00)	93(91.00)	4.49	0.213
	Radial Loop	1(1.50)	2(1.50)		
	Whorl	46(40.50)	35(40.50)		
	Arch	4(7.00)	10(7.00)		
Left ring	Ulnar loop	79(82.50)	86(82.50)	3.07	0.381
	Radial loop	1(1.00)	1(1.00)		
	Whorl	57(51.50)	46(51.50)		
	Arch	3(5.00)	7(5.00)		
Left thumb	Ulnar loop	62(60.00)	58(58.00)	2.39	0.496
	Radial loop	2(1.00)	0(1.00)		
	Whorl	68(71.00)	74(71.00)		
	Arch	8(8.00)	8(8.00)		

BAP: Bronchial asthma patient

Table 4.4 shows comparison of the digit length and 2D:4D between control and BAP attending MMSH. A statistically significant difference in the digit length was observed, with BAP having a shorter digit length than controls. However, when gender was taken into consideration, a significant difference was observed in the length of the right index (t = -2.11, *P*-value = 0.038), right ring (t= -2.44, *P*-value = 0.017) and left ring (t = -2.37, *P*-value = 0.021) digits but not the left index in males only. No significant difference in digit length was seen between BAP and control among female participants. Moreover, no significant difference was also seen in the 2D:4D of controls and BAP attending MMSH.

Table 4. 4 : Comparison of the digit length and 2D:4D between Control and BAP Attending MMSH

Gender	Digit length (mm) and ratios	BAP Mean ± SD	Control Mean ± SD	t-value	*P* -Value
All	Right index length	66.26 ± 6.30	68.78 ± 6.03	-3.42	0.001
	Right ring length	70.38 ± 6.45	73.12 ± 6.22	-3.61	<0.001
	Left index length	67.98 ± 6.12	70.07 ± 5.84	-2.92	0.004
	Left ring length	70.42 ± 6.52	73.01 ± 6.00	-3.47	0.001
	Right 2D:4D	0.94 ± 0.04	0.94 ± 0.04	0.13	0.898
	Left 2D:4D	0.97 ± 0.05	0.96 ± 0.04	1.19	0.235
Male	Right index length	68.10 ± 6.31	71.18 ± 6.64	-2.11	0.038
	Right ring length	71.94 ± 7.33	75.84 ± 7.05	-2.44	0.017
	Left index length	69.63 ± 6.22	72.16 ± 6.58	-1.75	0.084
	Left ring length	72.11 ± 6.52	75.58 ± 6.67	-2.34	0.021
	Right 2D:4D	0.95 ± 0.05	0.94 ± 0.04	1.00	0.319
	Left 2D:4D	0.97 ± 0.05	0.96 ± 0.04	1.17	0.245
Female	Right index length	65.76 ± 6.23	66.98 ± 4.84	-1.46	0.146
	Right ring length	69.96 ± 6.15	71.08 ± 4.59	-1.37	0.172
	Left index length	67.53 ± 6.04	68.50 ± 4.67	-1.20	0.232
	Left ring length	69.96 ± 6.47	71.09 ± 4.61	-1.34	0.184
	Right 2D:4D	0.94 ± 0.04	0.94 ± 0.04	-0.49	0.626
	Left 2D:4D	0.97 ± 0.05	0.96 ± 0.04	0.36	0.719

BAP; Bronchial asthma patient, SD; standard deviation,

n=110 (female BAP), n=30 (male controls), n= 80 (female BAP), n= 60 (male controls)

4.1.2 Differences in the Level of Pattern Concordance between Control and BAP Attending MMSH

Figure 4.1 shows the differences in the level of pattern concordance between control and BAP attending MMSH. It was observed that control have more pattern concordance than BAP, hence, pattern discordance is seen more among BAP, although this was not significant.

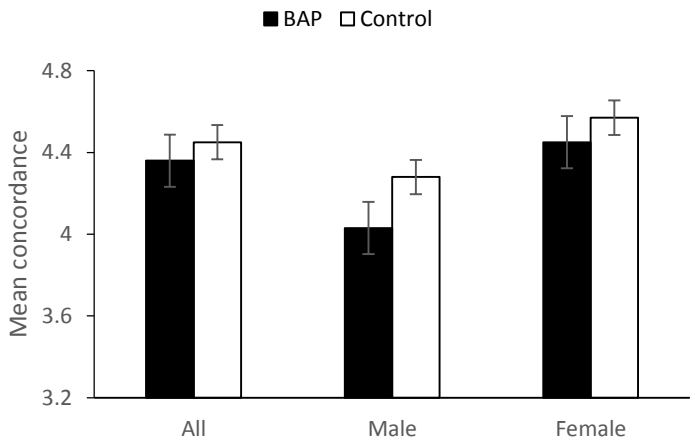


Figure 4. 1: Comparison of the Differences in the Level of Pattern Concordance between Control and BAP Attending MMSH

4.1.3 Difference in Fingerprint Ridge Density between Control and BAP Attending MMSH

Tables 4.5, 4.6 and 4.7 show the difference in fingerprint ridge density between control and BAP attending MMSH. The mean ridge densities among BAP and control indicated that BAP tend to have higher mean values in comparison to the controls.

Table 4.5 shows a significantly higher ridge density among BAP than control in the ulnar ridge density of the left little digit (10.77 ± 1.48 against 10.24 ± 1.38) and left ring digit (10.69 ±1.52 against 10.29±1.28). However, no significant difference was observed in the radial ridge density and the ridge density of the remaining digits.

As seen from table 4.6, among the male participants, a significant difference was observed in right index digit (Z = -0.75, P = 0.045) and left little (Z = -2.12, *P* = 0.034) ulnar ridge density. No significant difference in the ridge density was observed between BAP and control among female participant as seen from Table 4.7.

Table 4. 5 Differences in the Fingerprint Ridge Density between Control and BAP Attending MMSH

Ridge density per $25mm^2$ (both sexes)	BAP (n=180)		Control (n = 180)		Z- value	*P*- value
	Mean ± SD	Min- max	Mean ± SD	Min-max		
Left index ulnar	10.09±1.33	7-14	9.94±1.28	7-13	-0.84	0.400
Right index ulnar	9.60 ±1.34	7-13	9.46±1.23	7-13	-0.82	0.411
Left little ulnar	10.77±1.48	8-14	10.24±1.38	7-14	-3.01	0.003
Right little ulnar	10.06±1.33	7-13	9.91±1.14	8-13	-1.16	0.246
Left middle ulnar	10.08±1.43	7-14	10.02±1.43	6-14	-0.54	0.588
Right middle ulnar	9.77±1.48	7-14	9.5±1.20	7-13	-1.42	0.156
Left ring ulnar	10.69±1.52	7-14	10.29±1.28	7-13	-2.12	0.034
Right ring ulnar	9.99±1.56	7-13	9.83±1.28	7-13	-0.80	0.421
Left thumb ulnar	9.55±1.31	7-13	9.22±1.28	7-13	-2.21	0.27
Right thumb ulnar	9.25±1.29	6-13	9.08±1.19	7-13	-1.22	0.222
Left index radial	10.03±1.17	7-13	9.91±1.14	7-12	-1.09	0.275
Right index radial	10.11±1.23	8-13	9.98±1.15	7-14	-0.80	0.422
Left little radial	10.84±1.39	8-15	10.58±1.38	8-14	-1.24	0.216
Right little radial	10.71±1.29	8-14	10.67±1.37	7-15	-0.36	0.716
Left middle radial	10.09±1.36	7-14	9.83±1.36	6-13	-1.78	0.076
Right middle radial	10.16±1.35	7-14	10.11±1.33	7-13	-0.07	0.943
Left ring radial	10.44±1.39	6-14	10.2±1.21	7-15	-1.67	0.095
Right ring radial	10.56±1.37	8-14	10.39±1.41	7-14	-0.89	0.376
Left thumb radial	9.49±1.52	7-14	9.46±1.31	6-13	-0.14	0.887
Right thumb radial	9.53±1.34	6-13	9.39±1.24	6-12	-0.73	0.465

Max; maximum, Min; minimum, SD; standard deviation

Table 4. 6 Differences in the Fingerprint Ridge Density between Control and BAP Attending MMSH

Ridge density per 25mm^2 area (For male)	BAP (n=30)		Control (n=60)			
	Mean ±SD	Min-max	Mean ±SD	Min-max	Z- Value	P –Value
Left index ulnar	9.77±1.52	8-13	9.67±1.23	7-12	-0.23	0.819
Right index ulnar	9.60±1.40	7-13	9.33±1.10	7-12	-0.75	0.045
Left little ulnar	10.50±1.55	8-14	9.82±1.31	7-13	-2.12	0.034
Right little ulnar	10.07±1.44	8-13	9.80±1.15	8-12	-0.63	0.531
Left middle ulnar	10.00±1.51	7-13	9.78±1.32	6-13	-0.67	0.502
Right middle ulnar	9.77±1.65	7-13	9.35±1.07	7-12	-0.82	0.412
Left ring ulnar	10.37±1.59	8-14	9.95±1.23	7-13	-0.99	0.323
Right ring ulnar	10.00±1.41	8-13	9.78±1.17	7-12	-0.54	0.591
Left thumb ulnar	9.60±1.43	7-12	9.15±1.36	7-13	-1.56	0.12
Right thumb ulnar	9.30±1.56	7-13	8.92±1.15	7-12	-1.04	0.299
Left index radial	9.97±1.03	8-11	9.82±1.14	7-12	-0.73	0.464
Right index radial	9.87±1.22	8-13	9.70±1.24	7-14	-0.71	0.476
Left little radial	10.50±1.43	8-14	10.32±1.32	8-13	-0.45	0.652
Right little radial	10.50±1.25	8-13	10.25±1.28	7-14	-1.00	0.315
Left middle radial	9.93±1.36	7-13	9.57±1.23	6-12	-1.13	0.259
Right middle radial	9.87±1.22	8-13	9.97±1.33	7-13	0.73	0.466
Left ring radial	10.33±1.58	8-14	9.90±1.10	7-13	-1.15	0.250
Right ring radial	10.40±1.30	8-13	9.93±1.48	7-14	-1.56	0.120
Left thumb radial	9.33±1.63	7-13	9.40±1.36	6-13	-0.46	0.644
Right thumb radial	9.60±1.57	6-12	9.17±1.18	6-12	-1.23	0.218

Max; maximum, Min; Minimum, SD; standard deviation

Table 4. 7 Differences in the Fingerprint Ridge Density between Control and BAP attending MMSH

Ridge density per 25mm^2 area (For female)	BAP (n=110)		Control (n= 80)			
	Mean ±SD	Min-max	Mean ±SD	Min-max	Z	P-Value
Left index ulnar	10.17±1.26	7-14	10.14±1.28	8-13	-0.32	0.752
Right index ulnar	9.60±1.32	7-13	9.55±1.31	7-13	-0.18	0.856
Left little ulnar	10.85±1.46	8-14	10.56±1.35	8-14	-1.29	0.197
Right little ulnar	10.06±1.30	7-13	9.99±1.14	8-13	-0.72	0.474
Left middle ulnar	10.10±1.41	7-14	10.20±1.50	7-14	-0.14	0.890
Right middle ulnar	9.77±1.44	7-14	9.61±1.29	7-13	-0.70	0.483
Left ring ulnar	10.78±1.49	7-14	10.55±1.26	8-13	-1.02	0.308
Right ring ulnar	9.98±1.61	7-13	9.86±1.37	7-13	-0.55	0.580
Left thumb ulnar	9.54±1.28	7-13	9.28±1.22	7-13	-1.39	0.164
Right thumb ulnar	9.24±1.21	6-13	9.20±1.21	7-13	-0.44	0.663
Left index radial	10.05±1.21	7-13	9.97±1.14	8-12	-0.65	0.515
Right index radial	10.17±1.23	8-13	10.19±1.03	8-13	-0.20	0.840
Left little radial	10.93±1.37	8-15	10.78±1.41	8-14	-0.48	0.632
Right little radial	10.77±1.30	8-14	10.99±1.35	8-15	-1.07	0.284
Left middle radial	10.14±1.36	7-14	10.03±1.42	7-13	-0.82	0.411
Right middle radial	10.24±1.38	7-14	10.21±1.34	8-13	-0.05	0.961
Left ring radial	10.46±1.34	6-13	10.43±1.25	8-15	-0.34	0.732
Right ring radial	10.61±1.40	8-14	10.73±1.26	8-14	-0.77	0.439
Left thumb radial	9.54±1.50	7-14	9.50±1.27	6-13	-0.23	0.815
Right thumb radial	9.51±1.28	7-13	9.56±1.26	7-12	-0.34	0.732

Max; Maximum, Min; Minimum, SD ; standard deviation

4.1.4 Comparison of the Level of Fingerprint Ridge Density Asymmetry between Control and BAP Attending MMSH

Figure 4.2 compares the level of fingerprint ridge density asymmetry between control and BAP attending MMSH. A significant ($P < 0.05$) differences was seen in the ridge density asymmetry of the little digit where controls tend to have higher mean asymmetry (-0.34 ± 1.28) than the BAP (-0.71 ± 1.31). However, no significant difference was seen in the remaining digits.

Figure 4.3 compares the level of fingerprint ridge density asymmetry between male control and BAP attending MMSH. No statistically significant difference was seen in the ridge density asymmetry between BAP and control.

Figure 4.4 compares the level of fingerprint ridge density asymmetry between female controls and BAP attending MMSH. No significant difference was seen in the ridge density asymmetry between control and BAP.

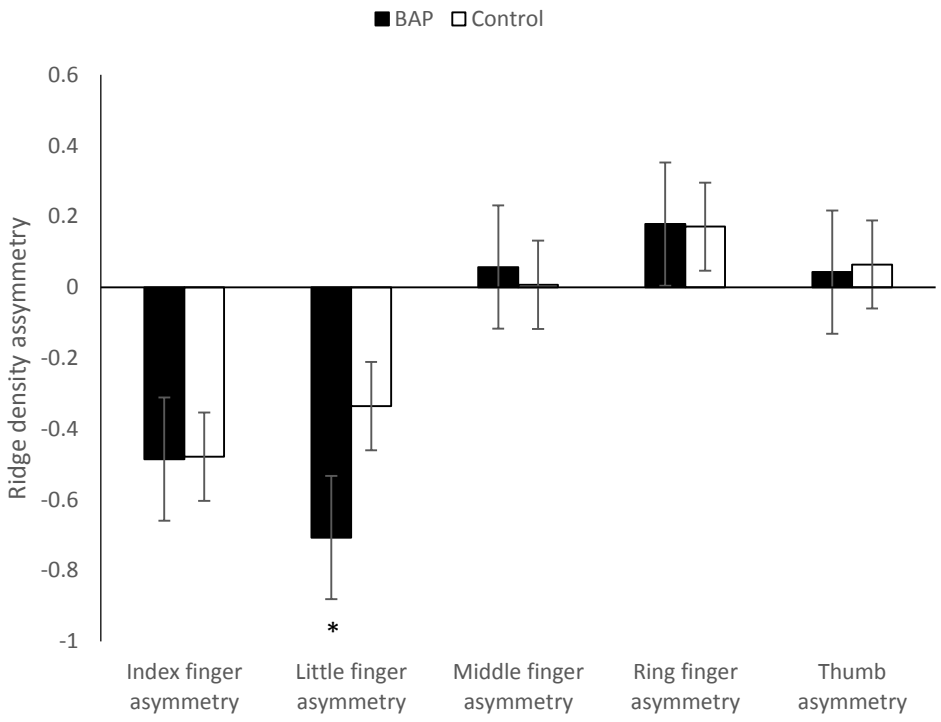


Figure 4. 2 : Comparison of the Level of Fingerprint Ridge Density Asymmetry between Control and BAP Attending MMSH

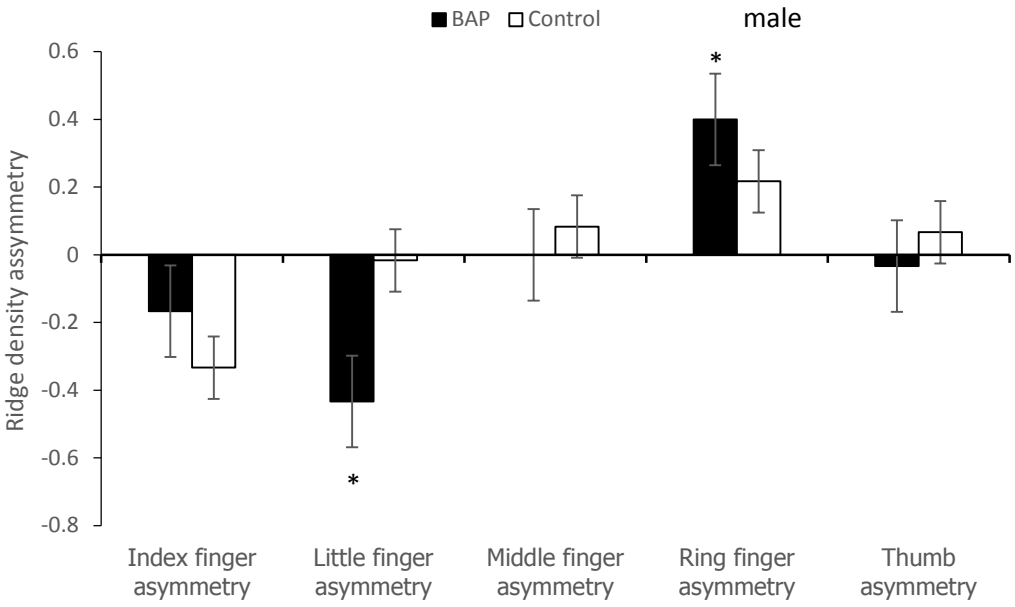


Figure 4. 3 Comparison of the Level of Fingerprint Ridge Density Asymmetry between Male Controls and BAP attending MMSH

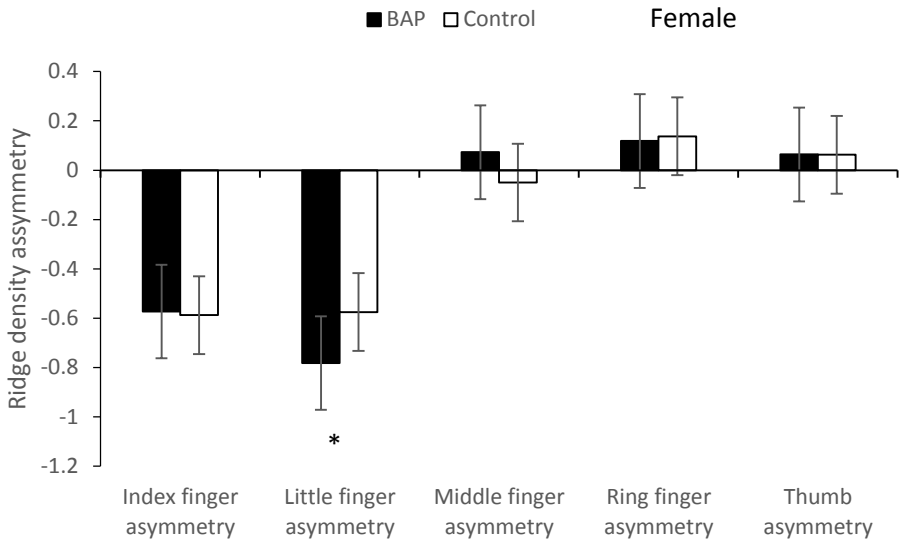


Figure 4. 4 Comparison of the level of Fingerprint Ridge Density Asymmetry between Female Controls and BAP Attending MMSH

4.1.5 Determination of the Cut-off Values of Ridge Density, Digit Length and 2D:4D that Discriminate between Control and BAP Attending MMSH

Table 4.8 shows the cut-off values, sensitivity and specificity of ulnar ridge density for discrimination between control and BAP attending MMSH. It was observed that the left little ulnar ridge density was the best predictor of bronchial asthma at cut off value of 10 ridge density per $25mm^2$ (AUC= 0.60, *P*= 0.003, sensitivity=81%, specificity= 32%, and YI = 1.14). Ridge density of $\geq$10 per $25mm^2$ in the left little digit indicate BAP, while <10 per $25mm^2$ indicate control.

Figure 4.5 shows receiver operating characteristics curve for discrimination between control and BAP using the ulnar ridge density. It was observed that the left little digit was the best discriminator between control and BAP (AUC=60%, P=0.003, sensitivity=81%, specificity=32% and YI=1.14).

Table 4. 8 Determination of the Cut-off Values, Sensitivity and Specificity of Ulnar Ridge Density that Discriminate between Control and BAP Attending MMSH

Ulnar RD per $25mm^2$	RD Cut-off values	Sensitivity (%)	Specificity (%)	YI	AUC (%)	SE	*P* Value
Left index	11	36	71	1.071	52.8	0.035	0.414
Right index	9	83	22	1.057	52.7	0.035	0.427
Left little	10	81	32	1.136	60.2	0.034	0.003
Right little	11	35	72	1.085	53.9	0.035	0.262
Left middle	10	66	39	1.057	51.8	0.035	0.597
Right middle	12	15	94	1.093	54.8	0.034	0.167
Left ring	12	29	84	1.129	57.2	0.034	0.038
Right ring	11	37	71	1.079	52.7	0.035	0.431
Left thumb	11	22	85	1.071	57.4	0.034	0.032
Right thumb	10	40	68	1.086	54.1	0.034	0.237

AUC; Area under the curve, SE; Standard error, RD; Ridge density asymmetry, YI; Youden index

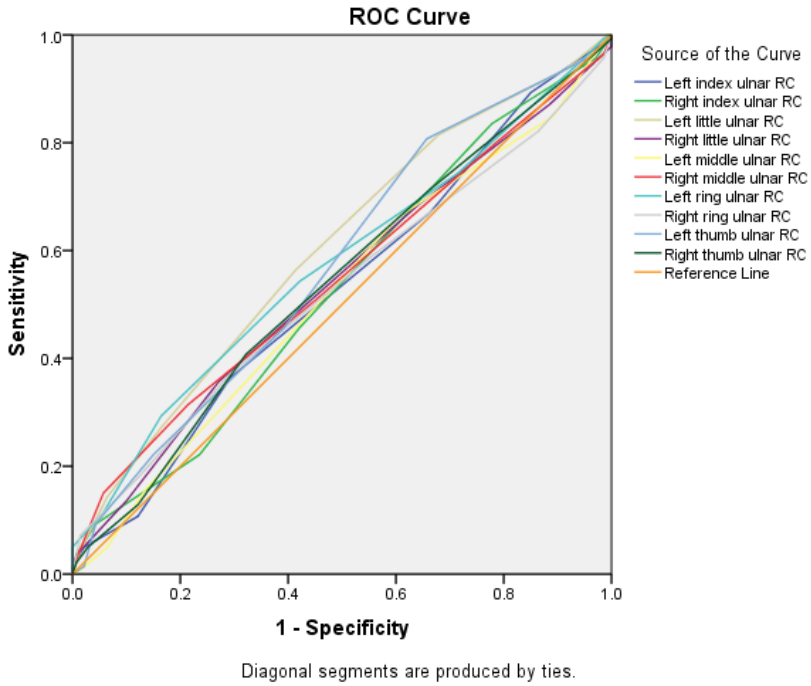


Figure 4. 5: Receiver Operating Characteristics Curve of Ulnar Ridge Density for Discrimination between Control and BAP attending MMSH

Table 4.9 shows cut-off values, sensitivity and specificity of radial ridge density for discrimination between control and BAP attending MMSH. It was observed that the left little and left middle digit have the highest YI (1.107), however, they were not significant in discriminating between control and BAP as the area under the curves were around 50%.

Figure 4.6 shows receiver operating characteristics curve of radial ridge density for discrimination between BAP attending MMSH. Radial ridge density has no discriminating potential in differentiating between control and BAP as AUC is 50%.

Table 4. 9 Determination of the Cut-off Values, Sensitivity and Specificity of Radial Ridge Density that Discriminate between Control and BAP attending MMSH

Radial RD per $25mm^2$	RD Cut-off Values	Sensitivity (%)	Specificity (%)	AUC (%)	SE	*P* Value	YI
Left index	11	35	70	53.6	0.035	0.292	1.050
Right index	11	36	70	52.7	0.035	0.438	1.057
Left little	10	86	25	54.2	0.034	0.227	1.107
Right little	12	26	77	51.2	0.035	0.724	1.028
Left middle	11	37	74	56.0	0.034	0.084	1.107
Right middle	9	93	13	49.8	0.035	0.944	1.058
Left ring	11	47	63	55.6	0.034	0.106	1.100
Right ring	10	81	27	53.0	0.035	0.388	1.085
Left thumb	10	53	51	50.5	0.035	0.89	1.043
Right thumb	11	23	83	52.4	0.035	0.48	1.058

AUC; Area under the curve, SE; Standard error, RD; Ridge density asymmetry, YI; Youden index

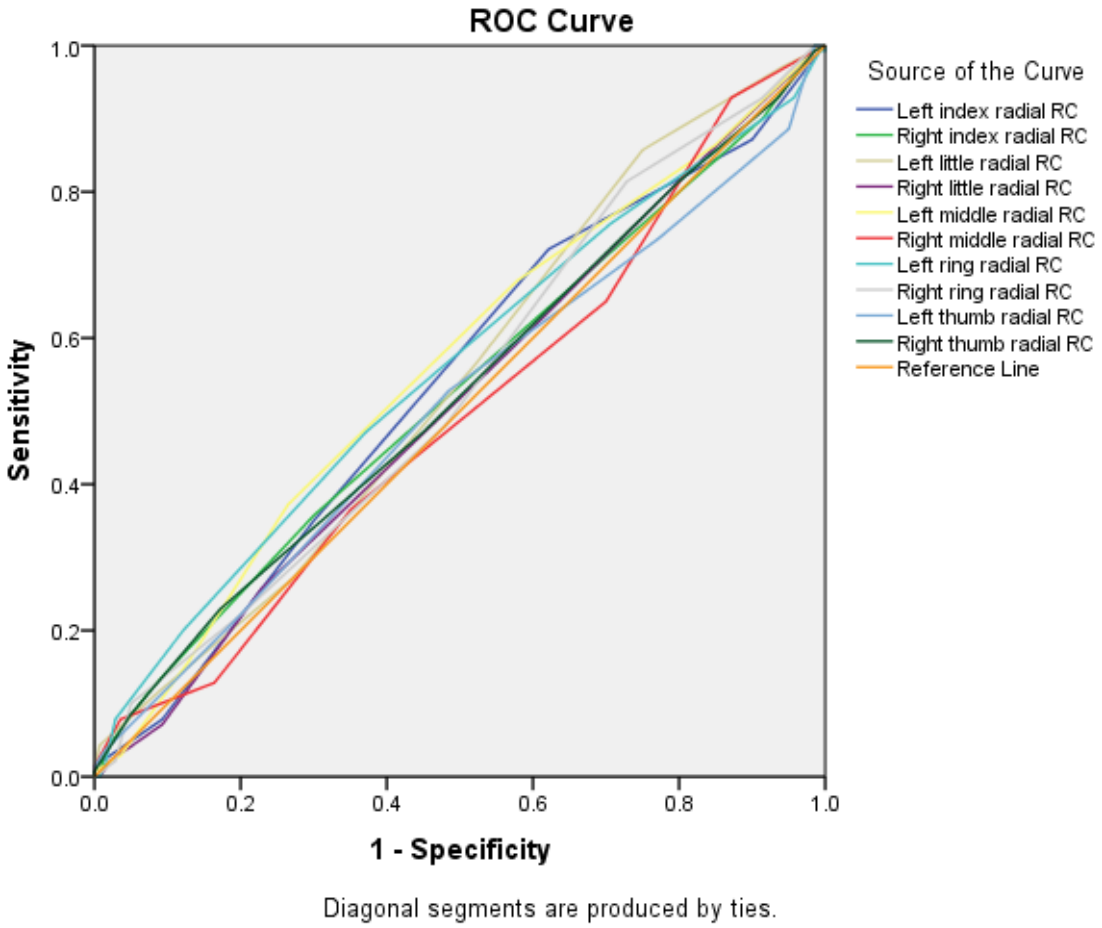


Figure 4. 6 : Receiver Operating Characteristics Curve of Radial Ridge Density for Discrimination between Control and BAP Attending MMSH

Table 4.10 shows the cut-off value, sensitivity and specificity of digit length and 2D:4D that discriminate between control and BAP attending MMSH. It was observed that the right 4^{th} digit was the best predictor of bronchial asthma at cut-off value of 70.54mm (AUC= 0.61, *P*= 0.001, sensitivity=66%, specificity= 51%, and YI= 1.178). Hence, right 4^{th} digit length of ≥71mm signified BAP.

Figure 4.7 shows receiver operating characteristics curve of digit length and 2D:4D for discrimination between control and BAP attending MMSH. It was observed that the right 4^{th} digit was the best discriminator of BAP (AUC =61%, *P*= 0.001, sensitivity=66%, specificity= 51%, and YI= 1.178).

Table 4. 10 : Determination of the Cut-off values, Sensitivity and Specificity of Digit Length and 2D:4D that Discriminate between Control and BAP attending MMSH

Digit length(mm) and ratio	Cut-off Values	Sensitivity (%)	Specificity (%)	YI	AUC (%)	SE	*P*-Value
Right index length	66.00	74	43	1.172	60.3	0.034	0.003
Right ring length	70.64	66	51	1.178	61.1	0.033	0.001
Left index length	70.27	48	69	1.165	59.5	0.034	0.006
Left ring length	75.11	37	83	1.200	60.0	0.034	0.004
Right 2D:4D	0.942	53	55	1.079	51.1	0.035	0.743
Left 2D:4D	0.987	29	78	1.065	49.1	0.035	0.800

AUC; Area under the curve, SE; Standard error, RD; Ridge density asymmetry, YI; Youden index

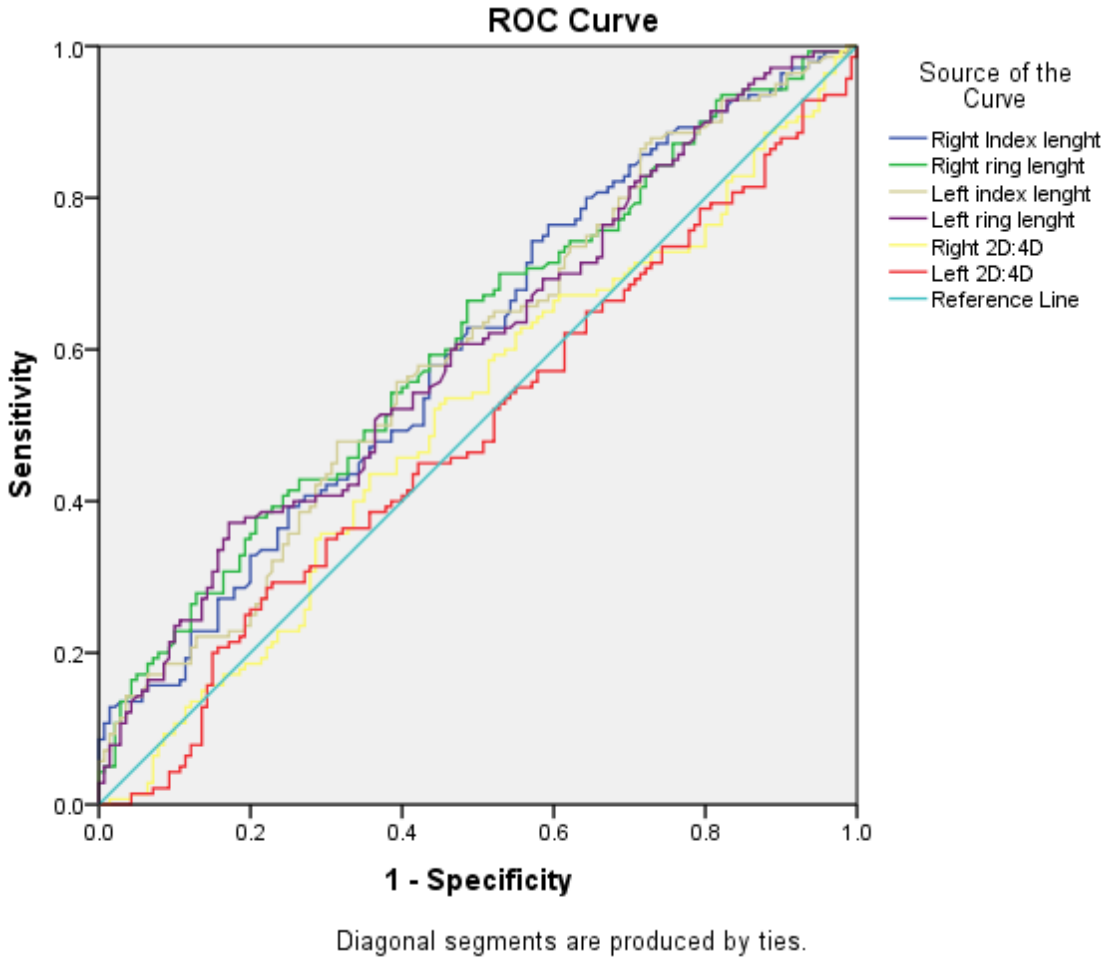


Figure 4.7 Receiver Operating Characteristics Curve of Digit Length and 2D:4D for Discrimination between Control and BAP Attending MMSH

4.2 DISCUSSION

The frequency of the fingerprint pattern for the entire study population (both BAP and control) of the present study agrees with universal distribution of fingerprint pattern where ulnar loop is the predominant pattern, followed by whorl, and arch (Galton , 1892; Cummins & Midlo, 1943). This shows that there is preservation of pattern frequency across different population and different geographical area. This is supported by the fact that post- natal environmental factor has less influence on fingerprint features (Babler, 1987). Although the pattern frequency are similar, the occurrence of the pattern type in different fingers might varies across and between population and in different disease condition. Hence the influence of heredity and intra-uterine environment on the fingerprint.

For BAP, it was observed that the index digit exhibited lesser frequency of ulnar loop and arch, and a higher frequency of whorl and radial loop. This result agrees with previous findings where whorl was found to be the predominant pattern in most digits of BAP. However, in a previous study, emphasis was placed more on the total number of whorls in all digits and the percentage of whorl on the thumb. Moreover, the ulnar loop, radial and arches were reported to be insignificant in determination of asthma (Sreenivasulu *et al.* , 2012). Similarly, a decrease in the number of arches in BAP (both male and female) and a significant decrease in the arches and the total loops (especially the radial loops) in female asthmatics than controls was observed. However, the whorls were found to be significantly increased in the female asthmatics than female controls while the ulnar loops in the male asthmatics were significantly less than that in the controls (Sandeep *et al.,* 2012). Moreover, findings of the present study are also in agreement with study done in Indian population by Gupta & Prakash (2003) where a reduction in the frequency of arches in both generations of bronchial

asthma patients and a higher frequency of whorls in the first digit of BAP was reported. However, a reduction in the frequency of arch but an increase in frequency of ulnar loop was also documented (Singh *et al*., 2016). In addition, the absence of radial loop in the thumb of control may also be considered as a good indicator of bronchial asthma.

It can be deduced that despite the variation in the frequency of pattern between BAP and control, there is no significant association between fingerprint pattern and bronchial asthma in most of the fingers except the index. Therefore, the fingerprint pattern as good discriminator of bronchial asthma is digit associated phenomenon. This is supported by previous study where only thumb was the digit to discriminate between BAP and control (Sreenivasulu *et al*., 2012). In the present study, the index finger is the best discriminator. This shows that there is a population specific difference which could be due to difference in genetic make-up and also environmental influence on the fingerprint formation *in-utero*.

It was previously reported that 2D:4D is related to lung functions which are both dependent on sex hormones. Male were found to have lower digit ratio than females, and it was observed that individuals with lower digit ratios tend to have decreased lung function. Therefore, it was suggested that digit ratio is a good predictor of airway function (Ho-Kee *et al.*, 2014). This is contrary to the finding of the present study where no significant difference in digit ratio was observed between the BAP and control. This might be because asthma is a chronic disease and in addition to sex hormones, genetics and intrauterine environment play a significant role in disease process. This may explain the observed insignificant difference in 2D:4D between BAP and control in the present study. Furthermore, it was revealed that testosterone

tend to play a role in protecting male against developing asthma by suppressing the production of an immune cells (innate lymphoid cell) that triggers allergic asthma. This explains why asthma is more prevalent in females than males after puberty, although, the reverse is the case before puberty (Seillet, Belz, & Guery, 2017). Since testosterone plays a role both in pathophysiology of asthma and digit formation, it can be suggested that those individuals with higher 2D:4D (low testesterone) are more likely to develop asthma than those with a lower 2D:4D (high testesterone). However, contrary to this, no relationship was seen between 2D:4D and asthma from the current study. This can be because multiple factors are involved in the pathophysiology of asthma in addition to the sex hormone (Bateman , Hurd , Barnes, Bousquet, & Drazen, 2008).

The significantly shorter digit length observed in the present study among BAP can be due to growth retardation that occurs in asthmatics due to either the disease processes or treatment with corticosteroid. Some studies (Synyder, Collipp, & Greene, 1967; Cohen & Abram,1940; Cohen, Weller & Abram, 1948) have proved the evidence of retarded growth in children with asthma. For instance, Snyder *et al.* (1967) reported that the growth impairment in children with asthma was associated with delay in bone maturation. Moreover, an adverse effect on growth was reported with the height being unaffected in milder cases of allergic disease, however with increasing severity, there was impaired growth as well as delay in sexual maturation (Cohen, Weller , & Cohen, 1940). In another study, Cohen, and Abram (1948) found out that satisfactory control of the disease was related to improve intake of energy as well as acceptable growth.

There was controversy as to whether growth retardation seen in asthmatics was due to asthma and its severity or it is from the use of inhaled corticosteroid. Studies have

shown that corticosteroid use might be the culprit in causing growth retardation in asthmatics rather than the disease process itself (Hauspie, Susanne, & Alexander , 1977 ; Cohen *et al*., 1940). However, there was no clear cut evidence as to whether the cause is from steroids or from the disease severity as growth retardation was ab initio noticed in the asthmatic children prior the introduction of corticosteroid (Ninan & Russell, 1992). Explanation of the relationship between asthma and growth has been linked to other factors: firstly, delayed maturation, prolongation and deepening of pre pubertal growth nadir seen in asthmatics. However, such effect doesn't have any significant effect on the final adult height (Hauspie *et al*., 1977). Secondly, impaired nocturnal growth hormone secretion that was assumed to occur because of night time symptoms that commonly occur in asthmatics result in sleep disturbance. However, result from analysis of 24hour growth hormone secretion profile of asthmatic children in Middlesex Hospital shows no evidence of reduction in growth hormone secretion (Morris , Jorgensen, Elrick, & Goldsmith, 1968). Lastly, coexisting endocrine malfunction which occur in some asthmatics. According to Ferguson *et al.* (1982) about half of asthmatic children with short stature had high concentration of triiodothyronine. However, further study was unable to confirm finding (Sole, Spinola, & Naspitz , 1989).

In the present study, no significant difference was seen in the fingerprint pattern (FP) concordance and ridge density asymmetry between BAP and controls, so also no significant difference was seen when sex was taken into consideration. Therefore, FP concordance and ridge density asymmetry are not good in discriminating Bronchial asthma patient from control. Even though concordance and ridge density asymmetry were found to be good indicators for other disease processes, such as in individuals with developmental disorder where asymmetry was used to assess developmental

delay (Naugler & Ludman, 1996) and other conditions such as schizophrenia (Mellor, 1992) and congenital cleft lip (Woois & Gianas, 1976). In line with the present study, no association was seen between concordance and other genetic diseases like type II diabetes mellitus (Ravindranath *et al*., 2005) and breast cancer (Prashant & Fatima, 2006).

The present study observed significant difference in ridge density between asthmatics and controls on some of the digits. This can be supported by the previous study where the absolute finger ridge count was found to be higher in BAP than the control (Sandeep *et al*., 2012). Despite the differences in methodology, fingerprint ridge density still exhibit potential in discriminating BAP and control. It can be hypothesized that the higher ridge density seen in asthmatics than control could be due to the fact that the body proportion of asthmatics are smaller than that of the normal individual due to growth retardation earlier reported to be seen among asthmatics (Cohen *et al*., 1940). As such equal number of ridges are accommodated among asthmatics in a smaller surface area, and hence, the higher ridge density seen among BAP.

Contrary to the present study, no significant difference was seen in the total finger ridge count between BAP and control (Amrut *et al*., 2011; Sandeep *et al.*, 2012). This means that methodological issue needs to be taken into consideration. Therefore, a universally defined methodological approach needs to be adopted to arrive at a better and definite conclusion.

It can be seen from the current study that the discriminating potential is only present on the ulnar area. It was proposed that the radial and ulnar sides of the fingers respond differently to developmental instructions (Jantz & Owsley, 1977). This might explain

why there was a difference in discriminating potential between the radial and ulnar ridge density on the same finger. So also, the ability of discrimination is more in males than female. This may be due to the fact that sex tend to play a role in ridge density. Studies have shown that there is a significant difference in the ridge density between male and female, with higher ridge density seen among females (Neeti & Ashish, 2014; Singh, 2012). To further explain this, the coexistence of a higher ridge density seen in both asthmatics and females may explain why it is difficult to discriminate female asthmatics from female controls. Moreover, it was earlier reported that ridge density varies according to sex, age, and population origin (Gutiérrez-Redomero, Alonso, & Dipierri, 2011). Hence, from the present study, when sex difference was put into consideration, a significant difference was seen in the ulnar ridge count of left little and right index digit of male asthmatics in comparison to controls. However, no statistically significant difference was seen among their female counterpart. The present observation may also be linked to genetic variation including the difference in chromosomal make up of male (XY) and female (XX). It is also likely that some associated genes of dermal ridges may reside in the X chromosome. If so, then having a double dose (XX chromosomes in females) of the same feature may lead to complete/strong penetrance (David, 1981). This led to the suggestion that sex chromosomes may be a factor influencing ridge density as it has also been reported to affect the size of the cells (Krishan, 2010).

Patient with ridge density of $\geq$ 10 ridges/ 25mm^2 are more likely to have bronchial asthma, while those with <10 ridges/25mm^2 are less likely to have bronchial asthma. This explains why asthma is more common among females as they tend to have higher ridge density. In adults, the prevalence of asthma is twice as high in women as men; however, the reverse is seen in children. This shift in the prevalence starts at

puberty, coinciding with sex hormone sprout (Malhaz, 2017). Female sex steroid was found to play a significant role in not only development of asthma but also allergic diseases via several mechanisms. Estrogen receptors are present on numerous immunoregulatory cells and estrogen's actions tilt immune responses toward allergy. It may act directly to produce deleterious effects in asthma, or indirectly through modification of several pathways. Not only do endogenous estrogens appear to play a role, but exogenous estrogens have also been implicated, and may enhance development of atopic disorders like asthma in humans (Rana, Bondsa, & Terumi , 2013). Androgen has been proposed to have a protective role in the development of allergic disease (Hayashi *et al.*, 2003).

CHAPTER FIVE

5.0 SUMMARY, CONCLUSION AND RECOMMENDATION

5.1 SUMMARY

The distribution of fingertip patterns in all the digits shows a lower frequency of arches in asthmatics than control. However, in first four fingers a higher frequency of whorl and lower frequency of ulnar loop is seen in BAP as compared to control. Whereas in the thumb, the reverse was seen (high frequency of ulnar loops and less frequency of whorl) in BAP than control. A significant difference was observed in the index finger pattern between BAP and control (Chi^2 = 9.94, *P* = 0.019), with BAP having lower frequency of ulnar loop (73% as compared to 78% in control) and arch (4% as compared to 15% in control), and higher frequency of whorl (59% as compared to 46% in control) and radial loop (4:1). It was observed also that radial loop was absent in the thumb of control group. A significant difference in the digit length was observed, with BAP having a shorter digit length than controls. However, when gender was taken into consideration, a significant difference was observed in the length of the right 2D (t = -2.11, P-value = 0.038), right 4D (t= -2.44, P-value = 0.017) and left 4D (t = -2.37, P-value = 0.021) digits among males only. No significant difference was seen in the pattern concordance between BAP and control. A higher ridge density was observed among BAP than control with a significant difference (*P* =0.003 and 0.034) in the ulnar ridge density of the left little (10.77 ± 1.48 against 10.24 ± 1.38) and ring fingers (10.69 ±1.52 against 10.29±1.28). However, no significant difference was observed in the ridge density of the remaining fingers. Furthermore, these differences were observed only among males in the right index (*P* = 0.045) and left little (*P* = 0.034) ulnar ridge density when sex was taken into consideration. A significant (P <0.05) differences was seen in the ridge density asymmetry of the little digit where controls tend to have higher mean asymmetry (-

0.34 ± 1.28) than the BAP (-0.71± 1.31). However, no significant difference was seen in the remaining fingers. However, in the ring digit, the mean asymmetry difference was higher among BAP (0.40±1.22) than control (0.22±0.96). It was observed that the left little ulnar ridge density was the best predictor of bronchial asthma at cut-off value of ≥ 10 ridge density per $25mm^2$ (AUC= 0.60, P= 0.003, sensitivity=81%, specificity= 32%, and Youden index of 1.14). Ridge density of ≥ 10 per $25mm^2$ in the left little signify BAP, while < 10 per $25mm^2$ signifies control. The right 4^{th} digit is the best predictor of bronchial asthma at cut off value of 70.54mm (AUC= 0.61, P= 0.001, sensitivity=66%, specificity= 51%, and a Youden index of 1.178). Hence, 4^{th} digit length of ≥71mm signifies BAP.

5.2 CONCLUSION

In conclusion, fingerprint pattern of the index digit, digit length and ulnar ridge density of left little and left ring digit are good indicators of bronchial asthma with left little ulnar ridge density and the right 4^{th} digit length being the best discriminators of BAP. However, the 2D:4D and pattern concordance have no significant role in discrimination between BAP and control.

5.3 CONTRIBUTION TO KNOWLEDGE

The utility of the present study in the field of medicine cannot be over-emphasized. We found out that the fingerprint of the index digit, the ridge density and the digit length hold potentials as a tool for predicting asthma. So also the ulnar ridge density of the left little and the length of the right 4^{th} digit hold a strong potential in discriminating BAP from control.

5.4 RECOMMENDATIONS

1. The findings from the current research should be use by clinicians and other health workers to screen for bronchial asthma. This will assist in primary prevention of asthma in countries where prevalence is high through early detection.
2. Further researches that utilizes other parameters of the fingerprint such as minutia, white lines, ridge depth among others need to be considered in order to assess their potentials in diagnosing asthma.
3. Similar study need to be done among different ethnic groups in order to assess whether there is ethnic variability of fingerprint parameters and digit ratio in determination of asthma.

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APPENDIX I

PROFORMA

ON THE EVALUATION OF THE POTENTIAL OF FINGERPRINT AND DIGIT RATIO IN SCREENING OF PATIENT WITH BRONCHIAL ASTHMA

QUESTIONAIRE CODE: _____ STATUS: _____

BIODATA:

- File no: _____
- Sex: Male ☐ Female ☐
- Age: _____
- Educational status: None ☐; nursery ☐ ; primary ☐ ; secondary ☐; others specify _____

MEDICAL HISTORY

- Family history of asthma: Yes ☐ No ☐
- Duration of the condition: _____
- History of allergic rhinitis: Yes ☐ No ☐
- History of allergic conjunctivitis: Yes ☐ No ☐

ANTHROPOMETRY

- RIGHT
  - Index digit length: _____
    - Right index ratio: _____
  - Ring digit length: _____

- LEFT
  - Index digit length: _____
    - Left index ratio: _____
  - Ring digit length: _____

APPENDIX II

CONSENT FORM

My name is Amina Danladi Muhammad an MSc student from the department of Anatomy, Bayero University Kano. I am carrying out a study on the evaluation of the potential of fingerprint and digit ratio in screening of patients with bronchial asthma. This will help in producing a non-invasive, simple screening tools that can be used to predict asthma in resource poor communities. It involves capturing of the fingerprint and measuring the length of two digits. Your participation will not cost you anything and will be highly appreciated. You have the right to opt out or refuse. This will not affect your management or care. Your data will be kept under strict confidentiality.

Thank you.

_____ _____

Participant's signature and date Researcher's signature and date

_____

Witness signature and date

APPENDIX III

KANO STATE OF NIGERIA
MINISTRY OF HEALTH
2nd & 3rd Floor, Post Office Road,
P.M.B. 3066, Kano.

Commissioner: 08023337417
Permanent Secretary: 09096619985
website: www.kanostateministryofhealth.gov.ng

Ref: MOH/Off/797/T.I/790 **Date:** 4nd July, 2018

Amina Danladi Muhammad,
Department of Anatomy,
Faculty of Basic Medical Science,
Bayero University,
Kano.

RE: APPLICATION FOR ETHICAL APPROVAL

Reference to your letter dated 12th June, 2018 on the above request addressed to the Chairman Health Research Ethics Committee of the Ministry requesting for ethical approval to conduct a Research work at Murtala Muhammad Specialist Hospital, Kano State.

2. The research entitled *"Evaluation of Fingerprint and Digit Ratio in Screening of Patient with Bronchial Asthma"* is for the Award of Masters Degree in Anatomy.

3. In view of the foregoing, I wish to convey the Ministry's approval for you to conduct the research at the above Mentioned Hospital, Kano.

4. You are also requested to share your findings with the Ministry of Health, Kano state.

5. Best Regards

Liti Gwarzo, Abdullahi
Ag. DPRS
Secretary (HREC)
For: Honourable Commissioner